

Bothalia

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BOTHALIA

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the Botanical Research Institute is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

Bothalia is vernoem ter ere van Generaal Louis Botha, eerste Eerste Minister en Minister van Landbou van die Unie van Suid-Afrika. Hierdie lyfblad van die Navorsingsinstituut vir Plantkunde is gewy aan die bevordering van die wetenskap van plantkunde. Die hoofgebiede wat gedek word, is taksonomie, ekologie, anatomie en sitologie. Een of twee dele van die tydskrif en 'n indeks van die inhoud, outeurs en onderwerpe verskyn jaarliks.

MEMOIRS OF THE BOTANICAL SURVEY OF SOUTH AFRICA MEMOIRS VAN DIE BOTANIESE OPNAME VAN SUID-AFRIKA

The memoirs are individual treatises usually of an ecological nature, but sometimes dealing with taxonomy or economic botany.

'n Reeks van losstaande omvattende verhandelings oor vernaamlik ekologiese, maar soms ook taksonomiese of plantekonomiese onderwerpe.

THE FLOWERING PLANTS OF AFRICA / DIE BLOMPLANTE VAN AFRIKA

This serial presents colour plates of African plants with accompanying text. The plates are prepared mainly by the artists at the Botanical Research Institute. Many well-known botanical artists have contributed to the series, such as Cythna Letty (over 700 plates), Kathleen Lansdell, Stella Gower, Betty Connell, Peter Bally and Fay Anderson. The Editor is pleased to receive living plants of general interest or of economic value for illustration.

Two parts of ten plates each are published annually. A volume consists of four parts. The publication is available in English and Afrikaans.

Hierdie reeks bied kleurplate van Afrikaanse plante met bygaande teks. Die skilderye word meestal deur die kunstenaars van die Navorsingsinstituut vir Plantkunde voorberei. Talle bekende botaniese kunstenaars het tot die reeks bygedra, soos Cythna Letty (meer as 700 plate), Kathleen Lansdell, Stella Gower, Betty Connell, Peter Bally en Fay Anderson. Die Redakteur verwelkom lewende plante van algemene belang of ekonomiese waarde vir afbeelding.

Twee dele, elk met tien plate, word jaarliks gepubliseer. 'n Volume bestaan uit vier dele. Die publikasie is beskikbaar in Afrikaans en Engels.

FLORA OF SOUTHERN AFRICA / FLORA VAN SUIDELIKE AFRIKA

A taxonomic treatise on the flora of the Republic of South Africa, Ciskei, Transkei, Lesotho, Swaziland, Bophuthatswana, South West Africa/Namibia, Botswana and Venda. The FSA contains descriptions of families, genera, species, infraspecific taxa, keys to genera and species, synonymy, literature and limited specimen citations, as well as taxonomic and ecological notes. Also available in the FSA series are the following:

The genera of southern African flowering plants by/deur R.A. Dyer, Vol. 1 Dicotyledons (1975); Vol. 2 Monocotyledons (1976).

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Plant exploration of southern Africa by Mary Gunn & L.E. Codd. Obtainable from/Beskikbaar van: A.A. Balkema Marketing, Box/Posbus 317, Claremont 7735, RSA.

'n Taksonomiese verhandeling oor die flora van die Republiek van Suid-Afrika, Ciskei, Transkei, Lesotho, Swaziland, Bophuthatswana, SWA/Namibië, Botswana en Venda. Die FSA bevat beskrywings van families, genusse, spesies, infraspesifieke taksons, sleutels tot genusse en spesies, sinonimie, literatuur, verwysings na enkele eksemplare, asook beknpte taksonomiese en ekologiese aantekeninge. Ook beskikbaar in die FSA-reeks is die volgende:

PALAEOFLORA OF SOUTHERN AFRICA / PALAEOFLORA VAN SUIDELIKE AFRIKA.

A palaeoflora on a pattern comparable to that of the Flora of southern Africa. Much of the information is presented in the form of tables and photographic plates depicting fossil populations. Now available:

Molteno Formation (Triassic) Vol. 1 Introduction. *Dicroidium* by/deur J.M. & H.M. Anderson.

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Obtainable from/Beskikbaar van: A.A. Balkema Marketing, Box/Posbus 317, Claremont 7735, RSA.

'n Palaeoflora met 'n uitleg vergelykbaar met dié van die Flora van suidelike Afrika. Baie van die inligting word aangebied in die vorm van tabelle en fotografiese plate waarop fossiele populasies afgebeeld word. Reeds beskikbaar:

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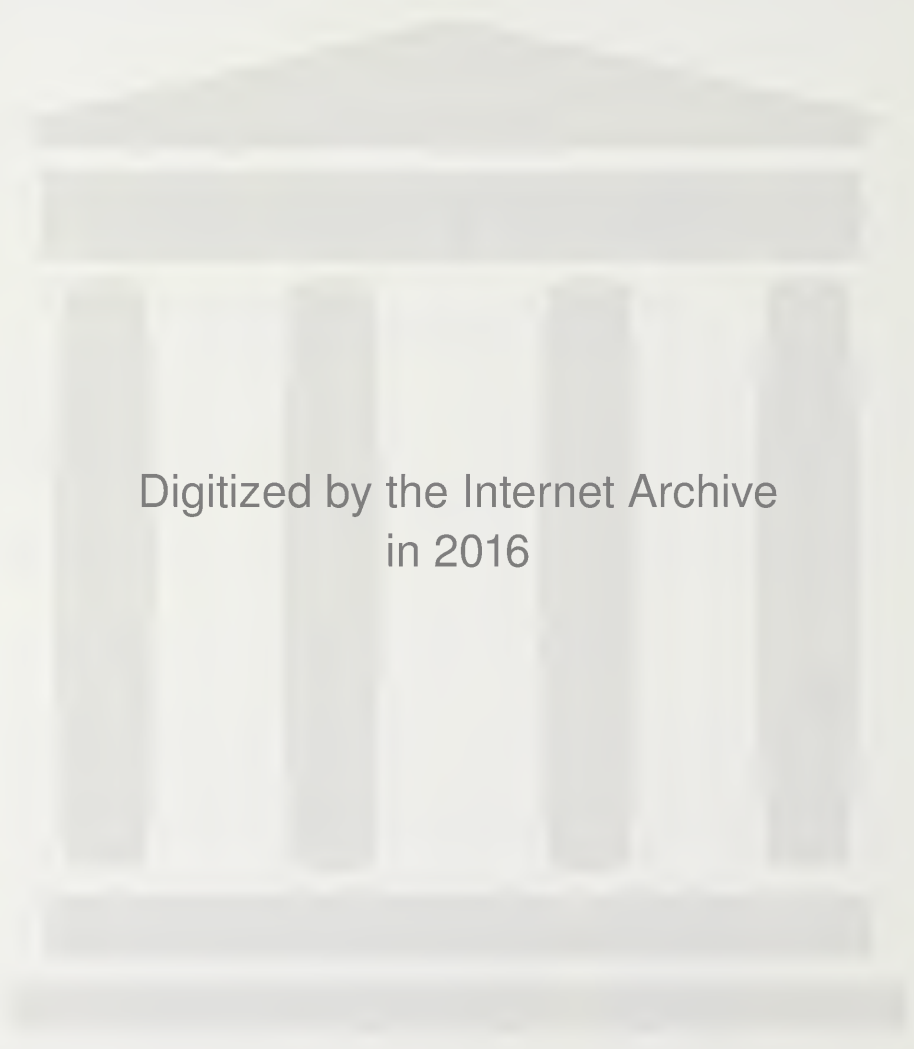
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The *Indigofera filifolia* complex (Fabaceae) in southern Africa

J. K. JARVIE* and C. H. STIRTON**

Keywords: Fabaceae, *Indigofera filifolia* complex, new species, southern Africa, taxonomy

ABSTRACT

The *Indigofera filifolia* Thunb. complex, previously known as a widespread polymorphic species, is segregated into three species. *I. filifolia* is retained as a variable species and two allied species, *I. gifbergensis* C. H. Stirton & J. K. Jarvie and *I. ionii* J. K. Jarvie & C. H. Stirton are described as new.

UITTREKSEL

Die *Indigofera filifolia* Thunb.-kompleks, voorheen bekend as 'n wydverspreide polimorfiese spesie, word in drie spesies verdeel. *I. filifolia* word as 'n veelvormige spesie behou en twee verwante spesies, *I. gifbergensis* C. H. Stirton & J. K. Jarvie en *I. ionii* J. K. Jarvie & C. H. Stirton word as nuut beskryf.

INTRODUCTION

The pantropical genus *Indigofera* comprises some 800 species. It forms a large and distinctive part of the tribe Indigoferae which also contains two closely related genera *Cyamopsis* and *Rhynchotropis* along with an anomalous Madagascan genus *Phylloxyon* (Polhill 1981).

Indigofera was once the main source of indigo dye but its importance dwindled as cheaper synthetic analogues were developed to replace the plant source of the dye. There is, however, a renewed interest in the genus and it has begun to be of some value as a source of forage legume (De Kort & Thijsse 1984).

The last major revision of *Indigofera* in Africa was by Gillett (1958), who recognized 278 species. He divided the African representatives into 5 subgenera, 5 sections and 19 subsections. As this revision was a precursor to a revision of the genus for the *Flora of Tropical East Africa* he treated only 70 species in any detail. The work is essentially regional and ignores to a considerable extent areas such as southern Africa.

Our overall knowledge of southern African species of *Indigofera* is still dependent on the 1862 revision by William Harvey. This account was subsequently added

to and modified by the following workers: Baker (1905), Brown (1925, 1926), Dinter (1932), Fourcade (1932), Bremekamp (1932), Guthrie, Pillans & Salter (1939), Dyer (1944), Suessenguth & Merxmüller (1951), Merxmüller & Schreiber (1957), Schreiber (1970) and Stirton (1982).

The present investigation focuses on the widespread polymorphic species *I. filifolia* in South Africa. Gillett (1958) placed *I. filifolia* Thunb. as the sole member of his section *Juncifolieae*. His diagnosis is limited to the presence of petioles many times longer than the small terminal leaflet, persistent when the latter falls off; fruiting pedicels erect and spreading; and endocarp spotted with seeds $\pm$ separated.

We are indebted to Mr Ion Williams for drawing our attention to a small aphyllous plant which did not appear to fit the description of *I. filifolia*. He felt certain that it represented a new species. We confirm this and name it *I. ionii* in his honour. As part of our study we also looked at all the available South African aphyllous specimens of *Indigofera* that seemed pertinent to the *I. filifolia* group. We conclude that what had been known as *I. filifolia* Thunb. in herbaria should be separated into three species: *I. filifolia* Thunb., *I. ionii* J. K. Jarvie & C. H. Stirton, and *I. gifbergensis* C. H. Stirton & J. K. Jarvie.

KEY TO SPECIES

- 1a Leaflets 3–5, terminal leaflet present, narrowly obovate to obovate, base obtuse; petiole 14–25 mm long; stipules narrowly triangular; flowers 5–6(7) mm long:
 - 2a Dense, erect shrub up to 1 m tall; leaflets recurved mucronate, obovate, biramous hairs present on lower surface but restricted to the margin; inflorescence 15–30-flowered; flowers brick-red; calyx-teeth finger-like, sinus between vexillar teeth narrow; standard broadly elliptic; peg on outer surface of keel blade pointing downwards; scales absent from base of anthers; upper parts of filaments uniformly thickened; seeds dark chestnut or khaki and covered in black blotches and stripes, elliptic..... 1. *gifbergensis*
 - 2b Small lax wiry herb, sparsely branched; leaflets with straight mucro, narrowly obovate, biramous hairs sparsely but evenly distributed over lower surface; inflorescence 6–10-flowered; flowers pink; calyx teeth triangular, sinus between vexillar teeth broad; standard very broadly ovate; peg on outer surface of keel blade pointing upwards; scales present at base of anthers; upper parts of filaments alternately thick and thin; seeds olive-green, oblong..... 2. *ionii*
- 1b Leaflets 6–8, upper leaflets absent or reduced to scales, elliptic, base cuneate; petiole 40–60 mm long; stipules filiform; flowers (7.5) 8.0–10.5 mm long..... 3. *filifolia*

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QUICK-KEY CHARACTERS

1. Flowers brick-red *I. gifbergensis*
Flowers pink *I. ionii*, *I. filifolia*
2. Leaflets with straight mucro *I. ionii*, *I. filifolia*
Leaflets recurved-mucronate *I. gifbergensis*
3. Anthers tufted; short filaments thicker than long filaments *I. ionii*, *I. filifolia*
Anthers without tufts, filaments uniformly thin ... *I. gifbergensis*
4. Peg on outer surface of keel blade pointing downwards ... *I. ionii*
Peg on outer surface of keel blades pointing upwards *I. gifbergensis*, *I. filifolia*
5. Fruits compressed *I. ionii*
Fruits terete *I. gifbergensis*, *I. filifolia*
6. Seeds dark chestnut or khaki, blotched *I. gifbergensis*
Seeds olive-green *I. ionii*
Seeds chocolate-brown *I. filifolia*

1. *Indigofera gifbergensis* C. H. Stirton & J. K. Jarvie, sp. nov. subsectioni *Juncifoliae* Gillettii proxima.

Frutex erectus lignosus ad 1 m altus, valde ramosus, caulibus veterioribus glabris, junioribus appresso-strigulosus glabrescentibus. *Stipulae* conferruminatae, basi petioli adnatae, ad 4 mm longae, anguste triangulares. *Folia* regularia, imparipinnata. *Foliola* obovata, 6–8 × 3,0–3,5 mm, basi obtusa, recurvato-mucronata. *Inflorescentiae* axillares, racemosae, laxae, 15–30-florae, sanguineae. *Flores* 5–6(7) mm longi, unoquoque bractea caduca anguste triangulari 2,0–2,3 mm longa subtenti. *Tubus calycis* 1,5 mm longus; lobi calycis omnes aequales triangulares. *Vexillum* late ellipticum, 5–6 × 4,0–4,5 mm. *Petala alarum* 5,5–6,0 × 2,0–2,5 mm. *Laminae carinae* 6 × 2–3 mm, manifeste saccatae. *Antherae* late apiculatae, ad 0,7–0,8 longae, squamis basilibus absentibus. *Pistillum* 5 mm longum, subtiliter fimbriatum. *Fructus* 25–30 × 2,5–3,0 mm, dehiscens; septa doliiformia, semina secedenta. *Semina* 2,5–2,7 × 1,7–1,8 mm, badia, maculis lineisque purpurascensibus.

TYPE.—Cape, Pilaarsberg, north of Pakhuis Pass, 9.1967, *Kerfoot* 5922 (NBG, holo.!).

Erect shrub up to 1 m tall, dense; woody below, half-herbaceous above; branches set close, stiff; appressed strigulose when young but glabrous when mature. *Sti-*

pules fused, adnate to base of petiole, up to 4 mm long, acute, glabrous. *Leaves* scarce, imparipinnate. *Leaflets* obovate, 3–5, 6–8 × 3,0–3,5 mm, base obtuse, apex recurved mucronate, glabrous above, covered in few flattened hairs around margin below. *Petiole* 14–15 mm long; petiolules 0,5 mm long. *Inflorescences* axillary, racemose, lax, 15–30-flowered; peduncle 60–140 mm long. *Flowers* 5–6 (7) mm long, red, each subtended by a 2,0–2,3 mm long, narrowly triangular, rapidly caducous bract; pedicel < 1 mm long. *Calyx* 2–3 mm long; tube 1,5 mm long; teeth equal, 1,5 mm long, triangular, sparsely fringed with flattened biramous hairs. *Standard* broadly elliptic, 5–6 × 4,0–4,5 mm; claw short; auricles absent; apex rounded; appendages absent. *Wing petals* 5,5–6,0 × 2,0–2,5 mm, upper part flattened near the margin, raised above but equal in length to the keel blades, few scattered hairs present. *Keel blades* 6 mm long, 2–3 mm wide at maximum, fringed along upper margin. *Androecium* 5 mm long; vexillar stamen free; anthers uniform, 0,7–0,8 mm long, broadly apiculate, anthers on long filaments basifixed, anthers on short filaments dorsifixed; scales absent. *Pistil* 5,0–5,5 mm long, glabrous, narrowly oblong, sessile, 7–8-ovuled; style upcurved, height of curvature 2 mm; stigma capitate. *Fruits* narrowly oblong, 25–30 × 2,5–3,0 mm, chestnut-brown, dehiscent; inner surface shiny white; septa up to 2 mm wide, barrel-shaped, separating the seeds, white with red flecks when in dry state. *Seeds* elliptic, 2,5–2,7 × 1,7–1,8 mm, dark chestnut or khaki, covered in large black blotches and stripes with small speckles in between; hilum exserted. Figure 1.

Indigofera gifbergensis is restricted to mountainous regions from Kobe Pass in the north to Cedarberg Sneekop in the south (Figure 2).

This mountain fynbos endemic flowers from late August to November. It occurs between 600–1 650 m.

CAPE.—3118 (Vanrhynsdorp): Gifberg (–DC), 10.1953, *Esterhuysen* 22084 (BOL); 9.1948, *Acocks* 12891 (K); 8.1948, *Compton* 20838 (NBG, STE); just before bridge over Snorkfontein River (–DC), 2.1979, *Snijman* 101 (MO, NBG, PRE); summit of Kobe Pass (–DB), 10.1973, *Hall* 4158 (NBG, PRE, STE). 3119 (Calvinia): Lokenberg, WSW of Calvinia (–CA), 8.1953, *Acocks* 16882 (PRE). 3218 (Clanwilliam): Langberg (–BA), 12.1951, *Bond* 1393 (NBG); 12.1941, *Esterhuysen* 7335 (BOL); Pilaarsberg, north of Pakhuis Pass (–BB), 9.1967, *Kerfoot* 5922 (NBG). 3219 (Wuppertal): Heuningvlei Forest



FIGURE 1.—*Indigofera gifbergensis* 1, flower, × 5,5; 2, calyx opened out, × 6,8; 3, standard opened out, × 8,2; 4, inner face of wing petal, × 8,2; 5, outer face of keel petal showing position and shape of the peg, × 8,2; 6, androecium flattened out, × 8,2; 7, pistil, × 8,2; 8, fruit with section cut away to show seeds and septa, × 2; 9, seed, × 6,8. 1–7: *Kerfoot* 5922. 8–9: *Leipoldt* 3366.

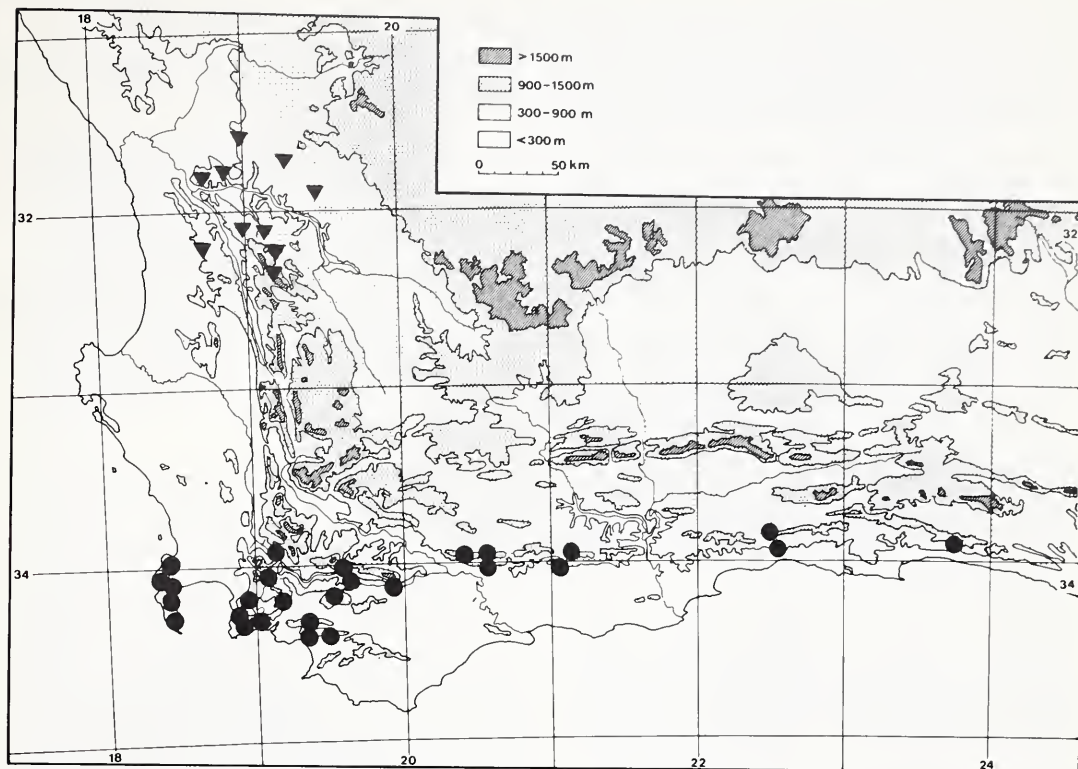


FIGURE 2.—Distribution of *Indigofera gibergerensis*, ▼; *I. filifolia*, ● in southern Africa.

Station along road to Groenberg (—AA), 10.1967, *Emdon 143* (PRE, STE); Pakhuis Mountain (—AA), 12.1940, *Leipoldt 3366* (BOL); 11.1929, *Thode A2112* (PRE); 9.1940, *Compton 9598* (NBG); 9.1937, *Compton 6939* (NBG); 12.1981, *Stirton 10196* (STE); Sneekop, Cedarberg (—CD), 2.1936, *Compton 6207* (NBG). Without precise locality: 8.1936, *Thorne s.n* (SAM 52691).

This distinctive species is easily separated from *I. filifolia* and *I. ionii* by its stiff compact habit, small brick-red flowers, the absence of tufts on anthers and its blotched seeds.

2. *Indigofera ionii* J. K. Jarvie & C. H. Stirton, sp. nov. subsectioni *Juncifoliae* Gillettii proxima. *I. filifoliae* Thunb. et *I. gibergerensis* C. H. Stirton & J. K. Jarvie affinis sed ab ambabus habitu humiliore, seminibus olivaceis, leguminibus compressis, sacco carinae deorsum curvato, differt.

Herba perennis decumbens usque 0,8 m alta. *Stipulae* liberae ad caulem appressae, glabrae. *Folia* juventute praesentia, imparipinnata, petiolata. *Foliola* anguste obovata, 3 (4 vel 5), 8–10 × 3–5 mm, lateralia minora, basi obtusa, apice mucronata, supra glabra, subtus sparse aequaliter pubescentia. *Petioluli* 15–25 mm longi. *Inflorescentiae* axillares, 6–10-florae, racemosae, laxae, 40–70 (80) mm longae. *Flores* 5–6 (7) mm longi, unoquoque bractea caduca anguste triangulari 2,5–3,0 mm longa subtenti; pedicellus filiformis, 2–3,5 mm longus. *Calyx* 3,0–3,5 mm longus; tubus 1,5–1,6 mm longus, glaber, dentibus 1,5 mm longis, ± aequalibus, triangularibus. *Vexillum* 5–7,0 mm longum et latum, transverse late ovatum; auriculae et calli absentes. *Alae* 6,8–7,0 × 2,5 mm, margine inferiore involutae; extremitas infera laminae incisa. *Petala carinae* 6,5–7,0 × 2,0–2,5 mm, apice pubescentia. *Androeceum* 6,0–6,5 mm longum;

stamine vexillari libero; antherae uniformes, <0,5 mm longae, ovatae, apiculatae, squamis basalibus praesentibus; filamenta antherarum basifixarum longa, tenuia; filamenta antherarum medifixarum, breviora, crassiora. *Pistillum* 5–6 mm longum, compressum, anguste oblongum, 8-ovulatum. *Fructus* 3,0–3,5 mm longus, compressus, dehiscens; septa <1 mm longa. *Semina* oblonga, 2–3 × 2 mm, olivacea.

TYPE.—Cape, Vogelgat, near Hermanus, *I. Williams 3519* (K, holo.!, NBG, iso.!).

Small wiry erect or sprawling herb up to 0,8 m tall; sparsely branched, mostly near the base. *Stipules* free, 2,5–3,0 mm long, appressed to stem, glabrous. *Leaves* present during early stages of growth, imparipinnate, petiolate. *Leaflets* 3, occasionally 4 or 5, narrowly obovate, 8–10 × 3–5 mm; terminal largest; base obtuse, apex mucronate, straight, glabrous above, sparsely and evenly scattered with biramous hairs beneath. *Petiole* 15–25 mm long; petiolule <1 mm long. *Inflorescences* axillary, 6–10-flowered, racemose, lax, 40–70 (–80) mm long. *Flowers* 5–6 (7) mm long, each subtended by a 2,5–3,0 mm long, narrowly triangular caducous bract; pedicel filiform, 2,0–3,5 mm long, elongating and thickening during fruit formation. *Calyx* 3,0–3,5 mm long, glabrous; tube 1,5–1,6 mm long; teeth 1,5 mm long, more or less equal, triangular; sinus between vexillar teeth broad. *Standard* 5,0–7,0 mm long and wide, very broadly ovate, claw very short, venation fine, branched from three traces at base, apex slightly emarginate; auricles and appendages absent. *Wing petals* 6,8–7,0 × 2,5 mm, infolded along lower margin; auricle inflated and flattened; with scattered hairs along the margin to-

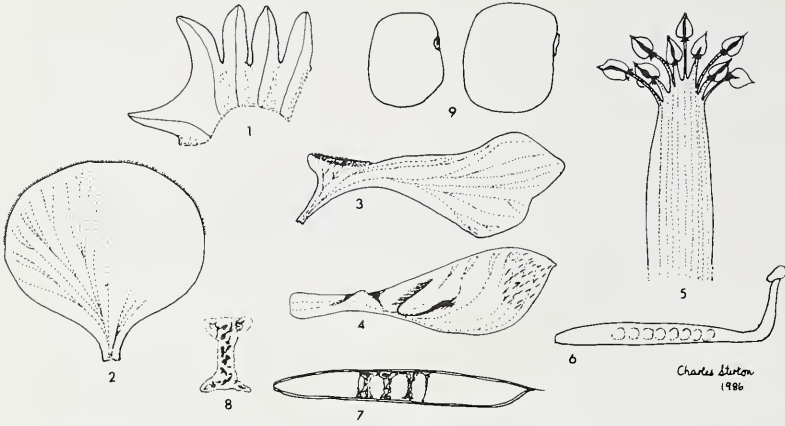


FIGURE 3.—*Indigofera ionii*. 1, calyx opened out, $\times 6,6$; 2, standard opened out, $\times 8$; 3, inner face of wing petal, $\times 8$; 4, outer face of keel petal showing position and shape of the peg, $\times 8$; 5, androecium flattened out, $\times 8$; 6, pistil, $\times 8$; 7, fruit with section cut away to show seeds and septa, $\times 1,3$; 8, septum, $\times 10$; 9, seeds, LHS seed from ends of the fruit and RHS seed from the centre of the fruit, $\times 8,6$. Voucher: Williams 3519.

wards the apex; lower end of blade notched. *Keel petals* 6,5–7,0 $\times$ 2,0–2,5 mm, apex pubescent. *Androecium* 6,0–6,5 mm long; vexillar stamen free; anthers uniform, $< 0,5$ mm long, ovate, apiculate, tufted at base; basifixed anthers on long thin filaments; medifixed anthers on short stout filaments. *Pistil* 5–6 mm long, compressed, $< 0,5$ mm long, glabrous, straight, narrowly oblong, 8-ovuled; style upcurved, height of curvature 1,5 mm. *Fruit* 30–35 mm long, compressed, surface coarsely rippled, margins distinctly ribbed, dehiscent; septa < 1 mm long, white with small orange flecks. *Seeds* oblong, 2–3 $\times$ 2 mm, olive-green. Figure 3.

Indigofera ionii is restricted to the mountains of the south-western Cape (Figure 4). This fugitive fynbos species favours damp areas, usually on tussocks in river beds, vleis and marshes. It flowers sporadically from August to April, with peaks between September and January. It occurs from 500–700 m.

CAPE.—3418 (Simonstown): plateau between Constantiaberg and Noordhoek (–AB), Levyns 6848 (BOL); west of Grootkop (–AB), 1.1940, Salter 8305 (BOL); Noordhoek Mountain (–AB), 11.1942, Barker 2091 (NBG); marsh west of Klaasjagersberg (–AB); 1.1936, Salter 5751 (BOL, BM, NBG); 8.1938, Salter 7606 (BM); Constantiaberg (–AB), 3.1940, Bond 192 (NBG); 9.1922, Schlechter 1469 (BOL); 12.1943, Compton 15463 (NBG); Redhill (–AB), 1.1940, Lewis 709 (NBG); source of Prinskasteel River (–AB), 1.1948, Salter 8302 (BOL); stream south of Constantiaberg (–AB), 11.1896, Wolley-Dod 1914 (K); Cape Point (–AD), 8.1944, Compton 15833 (NBG); near Smitswinkel (–AD), Levyns 6850 (BOL); Compton s.n. (BOL); Booskraal near Brightwater, Cape of Good Hope Nature Reserve (–AD), 12.1981, Grobbelaar 2647 (PRE); beacon near Smith's farm (–AD), 11.1939, Salter 8279 (BOL); Modderdam (–BA), 12.1938, Salter 7874 (BM, BOL, PRE); 12.1938, Salter 7875 (BOL); Muizenberg Mountain (–BB), 12.1948, Compton 21210 (NBG); Rooi Els Flats (–BD), 11.1945, Leighton 1448 (BOL); flats south west of Klein Hangklip (–BD), 9.1969, Boucher 566 (STE); near Somersfontein (–BD), 9.1969, Boucher 711 (STE). 3419 (Caledon): flats near Kleinmond (–AC), De Vos 855 (STE); Palmiet Valley near Albertyn's house (–AC), 10.1948, De Vos 1045 (STE); Vogelpool, Vogelgat, near Hermanus (–AD), 3.1984, Williams 3543 (K, NBG); Williams 3519 (K, NBG); 9.1984, Stirton 10762 (K); marshy slopes at head of Boskloof between Steenbras and Kogelberg (–BD), 2.1975. Esterhuysen s.n. (BOL). Without precise locality: Forbes s.n. (K).

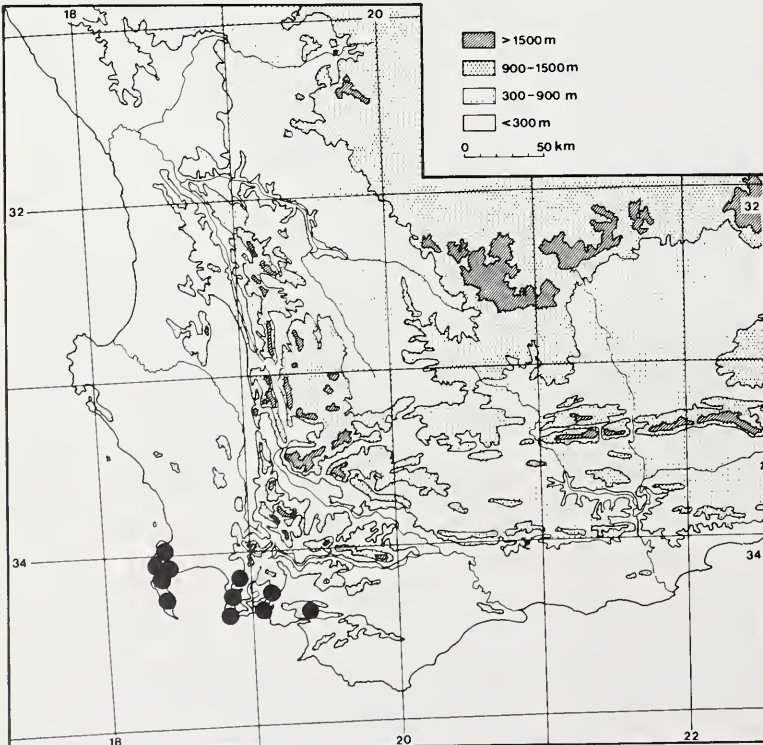


FIGURE 4.—Distribution of *Indigofera ionii* in southern Africa.

3. *Indigofera filifolia* Thunb., *Prodromus plantarum capensium*: 132 (1800); Thunb.: 595 (1823). Type: Cape, 'in collibus infra Tafelberg latere orientali', *Thunberg s.n.* (UPS-Thunb. 17338, holo., seen on microfiche).

Lebeckia contaminata Ker: 104 (1816) non Thunb. (1800). *L. contaminata* Ait.f.: 261 (1812) non Willd. (1803). *Indigofera filifolia* Ker: notes 2 (1817). *Spartium contaminatum* Ait.: 10 (1789) non L. (1771). Type: Cape of Good Hope, *Masson s.n.* (BM!, holo.).

Lebeckia nuda Sims: t. 2214 (1821). *Indigofera nuda* (Sims) G. Don: 301 (1850); G. Don: 209 (1832). Type: *Anonymous s.n.* Raised from Cape seeds in 1814 by Messrs. Whitley, Brame & Milne at the Fulham Nursery and then sent to Sims in October 1819 as *Lebeckia contaminata* (BM, holo.).

Indigofera aphylla Breit. ex Link: 251 (1822); Breit.: 209 (1817). Type: 'Kap der guten Hoffnung (Cape of Good Hope), cultivated in the Breiter Gardens in Leipzig and later by Link in Berlin, collector unknown (B, holo., destroyed).

Indigofera juncea DC.: 225 (1825); Mordant de Launay: 227, t. 227 (1820); Drapiez: 452, t. 452 (1834). Type: cultivated from seed sent from England, 24 Jul. 1818, *Cels s.n.* (G, holo.). Figure 5.



FIGURE 5.—Painting of *Indigofera juncea* DC. (*Cels s.n.*) = *I. filifolia*.

Tree-like shrub up to 2 m tall, open habit, woody; branches sparsely appressed strigulose when young but glabrous when mature. *Stipules* free, filiform, strigulose, up to 2 mm long, parallel to axis of branch. *Leaves* common on younger plants, petiolate, basal pair largest, upper pairs being reduced to scales. *Basal leaflets* 6–8, elliptic, rarely narrowly obovate, 15–20 × 8–10 mm; base cuneate; apex mucronate, straight; glabrous above, sparsely and evenly scattered with appressed biramous hairs beneath. *Petiole* 40–60 mm long; petiolules up to 2

mm long. *Inflorescences* axillary, clustered at ends of branches forming a pseudocompound structure, racemose, lax, up to 50-flowered. *Flowers* (7,5) 8,0–10,5 mm long, each subtended by a short 1–2 mm long, narrowly triangular, rapidly caducous bract; pedicel 4,0–4,3 mm long. *Calyx* 4,0–4,5 mm long; tube 1,7–3,4 mm long; teeth unequal, 1,1–3,0 mm long; triangular sinus between vexillar pair very broad, hairs few, scattered in the sinuses of the teeth. *Standard* (6,1) 8,4–9,2 (10,2) × (5) 6,3–7,6 mm, orbicular; claw very short; venation fine, branching from three traces at the base; apex slightly hooded, auricles and appendages absent. *Wing petals* 9–10 × 2,5–3,0 mm, constricted in the middle; auricle inflated and flattened. *Keel petals* 9 × 3,0–3,5 mm; apex pubescent. *Androecium* 9–10 mm long; vexillar stamen free; anthers uniform, 1 mm long, apiculate and tufted, anthers on long filaments basifixed, those on short filaments dorsifixed; scales present. *Pistil* 6,6–9,0 (9,9) mm long, terete, < 0,5 mm wide, glabrous, arched, narrowly oblong, 8–14-ovuled; style upcurved, height of curvature 2 mm. *Fruit* 40–55 × 4 mm, dark brown, dehiscent. *Seeds* 2,6–2,7 mm long and wide, chocolate-brown, hilum protruding, transversely oblong. Figure 6.

Indigofera filifolia is a widespread fynbos endemic occurring from the Cape Peninsula eastwards to Heidelberg (Figure 2). It favours damp sites and is especially common along watercourses. The plants flower throughout the year but with a peak from February to March. This species coppices strongly after burns.

CAPE.—3318 (Cape Town): valley behind Table Mountain (—CD), February, *Smuts 1083* (PRE); 3.1920, *Andreae 296* (STE); north of Window stream (—CD), 4.1956, *Esterhuysen 25652* (BOL, MO); St James, Cape Peninsula (—CD), 4.1914, *St. Clair Capron s.n.* (PRE); summit of Table Mountain (—CD), 3.1899, *Schoenberg 4867* (PRE); 3.1922, *Wilson 130* (STE); 3.1917, *Page s.n.* (PRE); 4.1907, *Kensit 68* (PRE); 2.1929, *Gillett 3527* (STE); *Kensit 68* (PRE); *Prior s.n.* (K); 4.1881, *Bolus 4778* (K, BM, BOL); 3.1947, *Barker 4445* (NBG); 3.1952, *Salter s.n.* (STE); 3.1910, *Worsdell s.n.* (K); 4.1929, *Hutchinson & Smuts 3190* (BM, K); Rondebosch (—CD), July, *Drège s.n.* (K). 3319 (Worcester): Franschhoek Pass (—CC), 3.1934, *Smuts & Gillett s.n.* (STE). 3320 (Montagu): Swellendam Forest Reserve (—CD), 1.1969, *Marsh 1110* (STE); below 12 o'clock Peak (—CD), 5.1963, *Taylor 4752* (PRE, STE); Barrydale Pass (—DC), *Van Breda 1518* (K, PRE); Tradouw Pass (—DC), 3.1954, *Balfour Browne 18* (BM). 3321 (Ladismith): Garcias Pass (—CC), 4.1935, *Esterhuysen 32484* (BOL); *Van Breda 1101* (K); 11.1814, *Burchell 6974* (K). 3322 (Oudtshoorn): Montagu Pass (—CD), 2.1944, *Fourcade 6367* (STE); 12.1949, *Martin 76* (NBG); 6.1927, *Fourcade 3245* (STE, PRE); 1.1897, *Guthrie s.n.* (NBG); lower Montagu Pass, between Toll House and bridge, 6.1943, *Fourcade 6020* (STE); on Postberg near George (—CD), 8.1814, *Burchell 5952* (K, BOL, PRE); 7.1912, *Rogers 4321* (BOL); *Prior s.n.* (K); 3.1928, *Maude s.n.* (K). 3323 (Willowmore): Coldstream (—DC), *Galpin 9565* (K). 3418 (Simonstown): Orange Kloof River (—AB), 2.1896, *Wolley-Dod 820* (BOL); 5.1953, *Salter 9558* (BM, MO); above Kalk Bay (—AB), 3.1896, *Wolley-Dod 1007* (BM, BOL); 4.1974, *Goldblatt 1399* (MO, PRE); Constantia Valley (—AB), 4.1886, *Thode 9* (PRE); 11.1938, *Salter 7852* (BOL); 3.1939, *Salter 8032* (BOL); Silvermine Plateau (—AB), 4.1974, *Goldblatt 1585* (MO, NBG, PRE); 3.1932, *Salter 2059* (BM, BOL); 3.1936, *Salter 5947* (BM); Simonstown (—AB), 5.1884, *Marloth 94* (PRE); 3.1935, *Minicki s.n.* (NBG); 3.1918, *Pillans 3488* (PRE); 8.1865, *Wright s.n.* (K); Hout Bay (—AB), *Prior s.n.* (K); 4.1955, *Baker 657* (BM, NBG); Blaauberg (—AB), *Drège s.n.* (K); Schusters Kraal (—AB), 3.1941, *Penfold s.n.* (NBG); flats at Smitswinkel vlei (—AD), 2.1961, *Thomas s.n.* (STE); Boys Kraal Rivier Vlei (—AD), 3.1946, *Compton 17940* (NBG); Bettys Bay (—BD), 3.1972, *Vogts s.n.* (STE); Palmiet Kloof, east of bridge (—BD), 3.1948, *De Vos 1299* (STE); 7.1950, *Parker 4491* (BOL, K, NBG); 7.1975, *Stirton 5013* (PRE); *Ebersohn 243* (NBG); Palmiet River Mountains (—BD), 1.1947, *Stokoe s.n.* (NBG); Rooi Els (—BD), 3.1948, *Parker 4319* (BOL, K, NBG); Elephant Rock Mountain (—BD), 3.1971, *Boucher 1464* (K, PRE, STE); Platbos Pass (—BD), March, *Boucher 1176* (K, PRE, SRGH, STE). 3419 (Caledon): Elgin (—AA), 4.1946, *Stokoe s.n.* (SAM 59572); Nuwekloof, Houwhoek Mountains (—AA), 3.1815, *Burchell 8052, 8134* (K); on the sides of the Bot River, near Houwhoek (—AA), *Bowes s.n.* (BM); Swartberg Mountain near Caledon (—AB), 9.1904, *Bolus s.n.* (BOL); Palmietberg (—AC), 3.1983, *Van Wyk 1142* (PRE); *Hermanus* (—AC), 4.1949, *De*



FIGURE 6.—*Indigofera filifolia*. 1, calyx opened out, $\times 6.8$; 2, standard opened out, $\times 8.2$; 3, inner face of wing petal, $\times 8.2$; 4, outer face of keel petal showing position and shape of the peg, $\times 8.2$; 5, androecium flattened out, $\times 8.2$; 6, pistil, $\times 8.2$; 7, fruit with section cut away to show seeds and septa, $\times 1.7$; 8, septum, $\times 6.8$; 9, seed, $\times 6.8$. Voucher: Williams 3542.

Waal s.n. (BOL, NBG); 4.1946, *Compton 17963* (BOL, NBG); 4.1980, *Orchard 545* (K, MO, PRE, STE); Cascade Pool, Vogelgat (–AD), 4.1984, *Williams 3542* (K); Sues Pool, Vogelgat (–AD), 4.1979, *Williams 2739* (MO, NBG, PRE); Vogelkloof, 4.1950, *Martin 322* (STE); Maanschiinkop (–AD), 4.1978, *Williams 2465* (MO, NBG); Babylon's Tower (–AD), 2.1941, *Esterhuysen 4974* (BOL); near Stanford, foot of Kleinrivier Mountains (–AD), 4.1952, *Stokoe s.n.* (NGB, STE); Boesmanskloof (–BA), 4.1983, *Forsyth 24* (PRE); Genadendal, Baviaanskloof (–BA), 3.1933, *Gillett 840* (BOL, STE); Riviersonderend (–BB), 4.1950, *Middlemost 1534* (NBG); Wynand Louw's Bos (–BD), 3.1963, *Van der Merwe 1357* (PRE, STE); Koudebergkloof near Nuwepos (–DA), 4.1975, *Oliver 5845* (PRE, STE). 3420 (Bredasdorp); Swellendam Mountain (–AB), 2.1941, *Compton 10600* (NBG); 4.1926, *Smith 2720* (PRE); 3.1930, *Thode 2318* (K); 1.1815, *Burchell 7401* (K); Hermitage Kloof (–AD), 12.1958, *Stokoe s.n.* (NBG). 3421 (Riversdale); Lemoenshoek Mountain near Heidelberg (–AA), 3.1948, *Stokoe s.n.* (SAM 61559). Without precise locality: Cape, *Harvey, s.n.* (BM, K); Cape Flats, February, *Ecklon & Zeyher s.n.* (SAM 32330); *Bowie s.n.* (BM); Langeberg Mountains, 4.1923, *Muir 2528* (PRE).

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A synopsis of *Tephrosia* subgenus *Barbistyla* (Fabaceae) in southern Africa

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Keywords: Fabaceae, key, Millettieae, new combinations, new species, Papilionoideae, southern Africa, subgenus *Barbistyla*, synopsis, *Tephrosia*, *T. brummittii*

ABSTRACT

A synopsis of the southern African species of *Tephrosia* Pers. subgenus *Barbistyla* Brummitt is given. Twenty-one species are recognized. A new species, *T. brummittii* B. D. Schire, is described and six new combinations are presented. The key is partly descriptive to provide diagnoses of the taxa and includes information on distributions. Vouchers are noted from at least three different herbaria to aid identification. Detailed notes are provided on atypical collections and taxa that require further investigation. Typification has been done as far as necessary to ensure that the names used are correct.

UITTREKSEL

'n Samevatting van die suider-Afrikaanse spesies van *Tephrosia* subgenus *Barbistyla* Brummitt word gegee. Een-en-twintig spesies word erken. 'n Nuwe spesie, *T. brummittii* B. D. Schire, word beskryf en ses nuwe kombinasies word voorgestel. Die sleutel is gedeeltelik beskrywend om diagnoses van die taksons te verskaf en bevat inligting oor verspreiding. Kontrole-eksemplare is van ten minste drie herbaria aangeteken om identifikasie te vergemaklik. Gedetailleerde notas word verskaf oor atipiese versamelings en oor taksons wat verdere ondersoek vereis. Tipifikasie is gedoen sover dit nodig was om seker te maak dat die name wat gebruik is, korrek is.

INTRODUCTION

Tephrosia is a pantropical genus in the tribe Millettieae (Papilionoideae) comprising over 400 species mostly from Africa. An overview of the nomenclatural history, systematic position, taxonomy and morphology of the genus is given by Bosman & De Haas (1983) and the most recent reviews of the tribe are by Geesink (1981, 1984).

In the Flora of southern Africa region it is estimated that there are 52 species eight subspecies and 10 varieties. There are at least three interspecific hybrids with the likelihood of more being found in the future.

My treatment of the genera closely allied to *Tephrosia* follows that by Brummitt (1980), i.e. *Requienia* and *Ptycholobium* are retained as separate genera whereas *Lupinophyllum* is sunk in *Tephrosia*.

Despite recent criticism by Geesink (1984) there is good reason for retaining the two subgeneric divisions in *Tephrosia* (Brummitt 1980). Although precise characters such as arrangement and position of hairs either along the style or just below the stigma, or the degree of style twisting, are variable, the two subgenera are characterized by flowers with different pollination strategies.

The salient features of each subgenus are summarized in the key below.

In subgenus *Barbistyla*, 21 species are recognized; a number of H.M.L. Forbes's (1948) species are reduced to synonymy or to subspecific status. The subgenus has a high degree of endemism in southern Africa with the *T. natalensis*, *T. macropoda*, *T. albissima* and *T. grandiflora* complexes almost all radiating exclusively within the Flora of southern Africa area. The three latter groups appear to be closely related to one another. It is however only these species in the subgenus that are endemic to us. The *T. longipes* complex and some of the other isolated species are more tropical in origin and they represent southerly extensions into the FSA area. A number of other areas of diversity for the subgenus occur in tropical Africa.

Selection pressures for evolutionary divergence at the generic level appear to have been centred on the breeding system. The subgeneric categories have different flower structures and this is reflected in their different pollination strategies. Within the subgenus *Barbistyla*, inflorescence characters (bracts) and fruit characters (pod size and seed position) separate the *T. grandiflora* allies from those of *T. longipes*. Inflorescence specialization has been particularly marked in the *T. grandiflora* alliance.

Flowers (4–) 6–13 (–18) mm long (from calyx across the keel), orange or pink; wings and keel distally curving upwards (the keel often appearing L-shaped); standard somewhat folded over the keel basally and curving upwards with the distal half reflexed; style glabrous, with or without a tuft of hairs just below the stigma subgenus *Tephrosia*

Flowers (11–) 14–24 (–30) mm long (from calyx across the keel), pink or mauve; wings and keel forwardly directed, obtriangular; standard generally straight, either folded over the keel or fully reflexed away from it; style pubescent, with or without a tuft of hairs just below the stigma subgenus *Barbistyla*

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- 5b Erect woody-stemmed subshrubs; pods narrowly oblong to lorate, $l:b \pm 6:1$; seeds transversely elongate with the longer dimension across the width of the pod:
- 13a Young stems canescent; stipules linear; pseudoracemes from short peduncles, elongate and laxly flowered; from E Swaziland 14. *T. gobensis*
- 13b Young stems sparsely to moderately pubescent; stipules narrowly triangular to lanceolate; pseudoracemes in pseudoheads at the ends of the peduncles; from E Transvaal, Natal to Transkei 21. *T. shiluanensis*
- 1b Stipules and flower bracts ovate to lanceolate, if stipules narrow then either auriculate at the base and with reflexed margins or somewhat narrower than the bracts:
- 14a Prostrate to ascending herbaceous plants with many slender stems arising from a woody rootstock; usually of open grassland and sandy places:
- 15a Peduncles less than 30 mm long; pseudoracemes elongated and laxly flowered; leaflets characteristically obtriangular to broadly obovate, up to 20 (–26) mm long; pods shortly oblong, (8–) 12–25 mm long with a rounded apex; seeds 2–4 (5), not transversely elongated; prostrate mat-forming herb; stems conspicuously spreading-pubescent; from N SWA/Namibia and N Transvaal 10. *T. radicans*
- 15b Peduncles longer than 30 mm; pseudoracemes with flowers often clustered at the ends of peduncles; leaflets variously shaped, up to 65 mm long; pods lorate, (20–) 25–60 mm long with acute apices; seeds more than 5, transversely elongated:
- 16a Buds completely enclosed by large, scarious navicular or trullate bracts 4–15 (–18) mm long (sometimes not quite masking the buds in *T. bachmannii*); pseudoracemes sparsely flowered with only 1–3 (4) flowers open at any one time:
- 17a Calyx densely white to yellow sericeous; leaflets abaxially canescent or sericeous; endemic to northern Pondoland/southern Natal sandstone region 15. *T. bachmannii*
- 17b Calyx shortly pubescent to spreading pilose; leaflets not as above:
- 18a Stipules maturing brown to dark brown, dying back and curling away from the stems; leaves 3–7-foliolate; leaflets obovate to narrowly obovate, 20–65 × 6–30 mm; OR (which includes var. *diffusa*) 5–9-foliolate with leaflets narrower, elliptic, 8–20 × 3–6 mm; widespread in the eastern half of the FSA area 11. *T. macropoda* sensu lato
- 18b Stipules maturing conspicuously red or brown, closely appressed to the stems; leaves 7–11 (–13)-foliolate; leaflets mostly narrowly oblong-elliptic or oblanceolate, (12–) 18–36 (–42) × 3–7 (–12) mm; from N Zululand and Swaziland Lowveld 12. *T. brummittii*
- 16b Buds visible and only partially masked by trullate, ovate to narrowly lanceolate bracts (1) 2–5 (–8) mm long; pseudoracemes compactly 2–8 (–10)-flowered:
- 19a Leaves with petiole and leaf rachis together longer than 25 mm (except occasionally in depauperate upland forms from the Kokstad-Harding region of E Griqualand); leaves never sessile; from Transkei to the Natal midlands 13a. *T. albissima* subsp. *albissima*
- 19b Leaves with petiole and leaf rachis together shorter than 25 mm; leaves often sessile and with very reduced rachides; from W Zululand and N Natal 13b. *T. albissima* subsp. *zuluensis*
- 14b Erect or bushy subshrubs 0.5–3.0 m high, with one to a few stems, woody at least at their bases; usually of scrub or forest margins, but where these vegetation types are evidently disturbed then plants untidy and scrambling:
- 20a Calyx shortly appressed white to yellowish sericeous; leaflets abaxially grey subsericeous to sericeous:
- 21a Leaflets very narrowly oblanceolate or, if broader than 40 mm then longer than 26 mm; bracts 1–10 (–12) mm long, about as long as wide, broadly ovate with rounded to acute apices, moderately to densely white sericeous; endemic from the sandstone outcrop region of N Pondoland/S Natal 15. *T. bachmannii*
- 21b Leaflets mostly shorter than 26 mm and wider than 40 mm; bracts (8–) 10–32 mm long, navicular or narrowly ovate, longer than wide with narrowly acute, more often acuminate apices; from the coastal belt of SW Cape to Natal south of Durban, inland to the Albany and Amatola regions of the E Cape 16. *T. grandiflora*
- 20b Calyx white to rufous pubescent, spreading pilose or villous; leaflets abaxially glabrous to canescent:
- 22a Bracts exceeding and completely enclosing young buds and also often the undeveloped apices of the pseudoracemes:
- 23a Stipules broadly ovate and conspicuously cordate at the base:
- 24a Compact, woody shrubs, largest stipules longer than 13 mm, characteristically chartaceous, maturing to purple or maroon, crowded and overlapping on new growth; from the Lydenburg and Barberton Districts of E Transvaal and Swaziland 19. *T. cordata*
- 24b Lax, short-lived perennials; largest stipules never longer than 13 mm, scarious, maturing reddish to brown; from the NE, E and SE Transvaal and N Natal, W Zululand to the Natal midlands 18b. *T. glomeruliflora* subsp. *meisneri*
- 23b Stipules ovate, not cordate at the base, or narrowly ovate to lanceolate and auriculate at the base, often with reflexed margins:
- 25a Bracts (–) (8–) 10–32 mm long, navicular or narrowly ovate, longer than wide with narrowly acute or more often, acuminate apices:
- 26a Stipules broadly ovate, closely appressed to the stems; bracts sparsely to moderately puberulent; from the coastal belt of SW Cape to Natal south of Durban, inland to the Albany and Amatola regions of E Cape 16. *T. grandiflora*
- 26b Stipules narrowly lanceolate to subulate, often with reflexed margins and spreading from the stem; bracts moderately to densely spreading pilose or villous; from the Eshowe to Inanda Districts of Natal 17. *T. inandensis*
- 25b Bracts 4–10 (–12) mm long, trullate, broadly ovate or orbicular, $\pm$ as long as wide with rounded, broadly acute or apiculate apices:

- 27a Calyx teeth narrowly subulate, 4–7 mm long, significantly longer than the tube; from the Barberton, Nelspruit and Komatipoort Districts of E Transvaal and Weza in E Griqualand 20. *T. subulata*
- 27b Calyx teeth triangular, lanceolate or subulate, 1,0–3,5 mm long, shorter than to slightly exceeding the tube:
- *28a Young inflorescences in dense glomerules at the ends of the peduncles; bracts flesh-coloured, minutely puberulent with a ciliate margin or short and densely white pubescent; calyx teeth triangular or appearing shortly subulate when dry, shorter than the tube except for the lowest tooth:
- 29a Stems densely appressed pubescent, becoming glabrous only with age; bracts and calyces moderately to densely white pubescent; from the coastal belt of Natal from Umzinto to N Zululand and inland to the Boston District of the midlands in the south and to the Hlabisa District in the north 18a. *T. glomeruliflora* subsp. *glomeruliflora*
- 29b Stems glabrous or only sparsely pubescent when young; bracts flesh-coloured, minutely-puberulent with a ciliate margin; calyces sparsely to densely white to rufous pubescent or pilose; from the NE, E and SE Transvaal and N Natal, W Zululand to the Natal midlands 18b. *T. glomeruliflora* subsp. *meisneri*
- †28b Young inflorescences in dense pseudoheads at the ends of the peduncles or pseudoracemes up to 100 mm long; if appearing glomerule-like then bracts white to yellowish spreading pilose; calyx teeth lanceolate-subulate, $\pm$ equal to the tube:
- 30a Youngest leaves densely spreading yellowish sericeous; bracts ovate-acuminate, (6) 7–12 mm long, densely white to yellowish pilose; from the Eshowe to Inanda Districts of Natal 17. *T. inandensis*
- 30b Youngest leaves densely appressed canescent; bracts ovate and apiculate, 4–7 mm long, sparsely to moderately white pilose; from the Shilovane, Pilgrims Rest and Lydenburg Districts of E Transvaal to N Natal, W Zululand and the Natal midlands from the Greytown through Pietermaritzburg to Harding Districts and the Transkei 21. *T. shiluwansensis*
- 22b Bracts never completely exceeding or enclosing young buds and only partially obscuring them in the pseudoracemes:
- 31a Calyx teeth broadly triangular, with acute apices, much shorter than the tube; bracts 1–3 mm long, obovate or ovate with truncate or rounded to apiculate apices, shortly and densely white pubescent; from the Boston and Durban Districts of Natal 18a. *T. glomeruliflora* subsp. *glomeruliflora*
- 31b Calyx teeth narrowly triangular to lanceolate or subulate with attenuate apices, $\pm$ equal to or exceeding the tube:
- 32a Calyx teeth narrowly subulate, 4–7 mm long, significantly longer than the tube; from the Barberton, Nelspruit and Komatipoort Districts of E Transvaal and Weza in E Griqualand 20. *T. subulata*
- 32b Calyx teeth lanceolate or subulate, 1,0–3,5(–4,0) mm long, more or less equal to the tube:
- 33a Youngest leaves densely appressed canescent; bracts 1–6 mm long, minutely puberulent to sparsely pubescent; calyx lobes often maturing bristle-like and reflexed apically; from the Shilovane, Pilgrims Rest and Lydenburg Districts of the E Transvaal to N Natal, W Zululand and the Natal midlands from the Greytown through Pietermaritzburg to Harding Districts and the Transkei 21. *T. shiluwansensis*
- 33b Youngest leaves densely spreading yellowish sericeous; bracts (6–) 7–12 mm long, densely white to yellowish pilose; calyx lobes not as above; from the Eshowe to Inanda Districts of Natal 17. *T. inandensis*

SYNOPSIS OF SPECIES

1. *Tephrosia retusa* *Burt* *Davy*, Flowering plants and ferns of the Transvaal 2: xxxi + 378 (1932). Type: Transvaal, Barberton, juxta Kaap River, *Bolus* 7724 (K!, BOL).

Distribution: E Transvaal and Swaziland.

Vouchers: *Bolus* 11821 (K, BOL); *Elan-Puttick* 254 (PRE); *Liebenberg* 3317 (K, PRE); *Pott* 5326 (PRE); *Rogers* 24827 (K, PRE).

2. *Tephrosia cephalantha* *Welw. ex Bak. var. decumbens* *Welw. ex Bak. emend. Brummitt* in Boletim da

Sociedade Broteriana, sér. 2, 41: 384 (1968). Type: Angola, Huíla, Ferrão da Sola, *Welwitsch* 2090 (K!).

Distribution: SWA/Namibia and Botswana.

Vouchers: *De Winter* 2801 (K, PRE); *De Winter & Marais* 4539 (K, PRE); *Holub s.n.* (K); *Merxmüller & Giess* 1864 (K); *Smith* 2311 (K).

3. *Tephrosia aequalata* *Bak. subsp. australis* *Brummitt* in Boletim da Sociedade Broteriana, sér. 2, 41: 358 (1968). Type: Zimbabwe, Melsetter Distr., *Williams* 146 (K, holo.!, PRE!, SRGH).

Distribution: NE Transvaal.

Vouchers: *Codd* 3040 (K, PRE); *Hanekom* 2283 (K, PRE); *Hemm* 182 (K, PRE); *Scheepers* 341 (K, PRE); *Taylor* 646 (K, PRE).

Note

This species was confused by H. M. L. Forbes: 990 (1948) with *T. zombensis* *Bak.*

* The term glomerule, used to describe certain juvenile inflorescences in the key, refers to the spherical or globose body located at the ends of peduncles which is formed by the compact arrangement of broadly ovate to orbicular bracts with rounded, apiculate or broadly acute apices.

† The term pseudoheads is used when inflorescences are congested at the ends of the peduncles but either the bracts are too small to completely enclose the young buds or the apices project out from the inflorescence because they are sharply acute to acuminate.

4. *Tephrosia longipes* Meisn. in Hooker's London Journal of Botany 2: 87 (1843). Type: Natal, in graminosis ad latera montium Tafelberge, Port Natal, Krauss 20 (K, holo.).

4a. subsp. *longipes*.

Brummitt in Boletim da Sociedade Broteriana, sér. 2, 41: 309 (1968).

Tephrosia lurida Sond.: 30 (1850). Type: Transvaal, Moorivier, Magaliesberg, Crocodile River, Zeyher 456 (K, isosyn.!).

Tephrosia angustissima Engl.: 29 (1888). Type: Cape, pr. Kuruman, in summo montium 'Ga Mhana', Marloth 1086 (B, BOL, GRA, PRE!, SAM).

Distribution: widespread in S Botswana, Transvaal, OFS, Natal and N Cape.

Vouchers: Brenan & Vahrmeijer 14255 (K); Codd 2661 (K, PRE); Germishuizen 133 (K, PRE); Rogers 18129 (K, PRE); Wood 1202 (K).

Notes

(1) The typical subsp. is maintained because of the occurrence of subsp. *swynnertonii* (Bak. f.) Brummitt: 315 (1968) in eastern Zimbabwe.

(2) A great deal of confusion has arisen in the past concerning the *T. longipes*-*T. lurida* complex. Forbes (1948) and Brummitt (1968) treated the two as separate species while Gillett (1958) placed *T. lurida* as a variety of *T. longipes*. Present research has shown that traditional characters used to separate them are based on ecological variables which cannot be reliably upheld taxonomically.

(3) A number of varieties have been described in this complex, i.e. *T. longipes* var. *uncinata* Harv.: 209 (1862). Type: Transvaal, Pretoria Distr., in nemorosis ad Aapies R., Zeyher 455 (BM, GRA, K!, SAM); *T. longipes* var. *icosisperma* Brummitt: 313 (1968), e.g. Moss & Rogers 523 (K) from Komatipoort, Transvaal; *T. lurida* var. *lissocarpa* Brummitt: 320 (1968). Type: Transvaal, Soutpansberg, ± 9 miles E of Louis Trichardt, Farm Rustfontein, Schlieben 7339 (K, holo.!) and *T. lurida* var. *drummondii* Brummitt: 321 (1968), e.g. Liebenberg 3313 (PRE) from Farm Schagen, Nelspruit, Transvaal. More field work is necessary to establish the validity of these varieties in the Flora area and they are not considered in this preliminary treatment.

(4) This complex together with the following species, i.e. *T. reptans* Bak., *T. caerulea* Bak. f., *T. euprepes* Brummitt and *T. euchroa* Verdoorn forms a clearly recognizable assemblage that is widespread in tropical Africa, and with the exception of *T. longipes* Meisn. only occurs in the northern extremities of the Flora area.

5. *Tephrosia euchroa* Verdoorn in Bothalia 3: 239 (1937). Type: Transvaal, Soutpansberg Distr., rocky NW slopes of Soutpansberg, Obermeyer, Schweickerdt & Verdoorn 73 (PRE, holo.!: K!).

Distribution: N Transvaal.

Vouchers: Acocks 16762 (K, PRE); Gertenbach 4914 (PRE); Pienaar 287 (K, PRE); Smuts & Gillett 4080 (K, PRE); Van der Schijff 1824 (PRE).

6. *Tephrosia euprepes* Brummitt in Boletim da Sociedade Broteriana, sér. 2, 41: 292 (1968). Type:

Zimbabwe, western Div., Nyamandhlovu Distr., Bon-golo, West 2694 (SRGH, holo.!: K!).

Distribution: N Botswana.

Vouchers: Allen 299BCD (K); Lugard 152, 175 (K); Rand 19, 20 (BM).

7. *Tephrosia caerulea* Bak. f., Leguminosae of Tropical Africa 1: 197 (1926). Type: Zambia, Mazabuka, Woods 51 (BM, holo.!).

7a. subsp. *caerulea*.

Distribution: N Botswana.

Vouchers: De Winter 4406 (K, PRE); Smith 2211 (K).

7b. subsp. *otaviensis* (Dinter) Schreiber & Brummitt in Boletim da Sociedade Broteriana, sér. 2, 41: 292 (1968).

Tephrosia otaviensis Dinter in Feddes Repertorium 30: 204 (1932). Type: SWA/Namibia, Hereroland, Klein Otavi, Dinter 5747 (NH, iso.!: K, photo.!).

Tephrosia longipes sensu Schreiber: 298 (1957).

Distribution: SWA/Namibia and N Botswana.

Vouchers: De Winter & Marais 4832 (K); Dinter 7570 (K); Müller & Biegel 2305 (K).

8. *Tephrosia reptans* Bak. in Oliver, Flora of Tropical Africa 2: 121 (1871). Types: Tanzania, Tabora Distr., nr Tabora, Speke & Grant s.n. (K, lecto.!) and Mozambique, Shupanga, Kirk s.n.

8a. var. *reptans*.

Brummitt: 284 (1968).

Distribution: NE Transvaal.

Vouchers: Smalberger 29 (PRE); Stephen 303 (PRE).

Note

Lectotypification by Brummitt: 283 (1968).

9. *Tephrosia natalensis* H. M. L. Forbes in Bothalia 4: 988 (1948). Type: Natal, Howick, Wood 8341 (NH, holo.!: K!).

9a. subsp. *natalensis*.

Tephrosia apiculata H. M. L. Forbes: 989 (1948). Type: Natal, Paulpietersburg Distr. between Paulpietersburg and Sunkelsdrift, Acocks 11749 (NH, holo.!: K, photo.!).

Distribution: S Transvaal, Swaziland, N Natal and Natal midlands.

Vouchers: Arnold 252 (K, PRE); Compton 29168 (K, PRE); Devenish 1722 (K, PRE); Schrire 1289, 2254 (NH).

9b. subsp. *pseudocapitata* (H. M. L. Forbes) B. D. Schrire, comb. et stat. nov. *Tephrosia pseudocapitata* H. M. L. Forbes in Bothalia 4: 988 (1948). Type: Natal, Greytown Distr., Wylie s.n. (NH21787) (NH, holo.!: K!).

Distribution: Natal midlands.

Vouchers: Buthlezi 332 (NH); Stirton 5203 (K, PRE); Wilms 1940 (K); Wylie s.n. (NH27992) (K, NH).

Note

The *T. natalensis* group may be an isolated ally of the complex comprising species numbered four to eight.

10. ***Tephrosia radicans* Welw. ex Bak.** in Oliver, Flora of Tropical Africa 2: 121 (1871). Type: Angola, Huilla, in pratis humidis ad formicar monticul de Varzeas e Catumba, *Welwitsch* 2082 (BM, holo. !; K!).

Distribution: SWA/Namibia and N Transvaal.

Vouchers: *De Winter & Marais* 4992 (K, PRE); *Galpin* 8959 (K, PRE); *Rehmann* 5529 (K); *Schlechter* 4679 (K); *Van Vuuren* 1411 (K, PRE).

11. ***Tephrosia macropoda* (E. Mey.) Harv.** in Harv. & Sond., Flora Capensis 2: 210 (1862). Syntypes: E Cape, inter Kachu et Zandplaat, *Drège s.n.* (B); Transkei, inter Gekau et Basche, *Drège s.n.* (K!); inter Umtata et Umgazana, *Drège s.n.* (K!). See note (1) below.

Apodynomene macropoda E. Mey.: 112 (1836). *Apodynomene macropoda* E. Mey. var. *latifolia* E. Mey.: 112 (1836).

Apodynomene macropoda E. Mey. var. *angustifolia* E. Mey.: 112 (1836). Type: Transkei, in collibus graminosis prope Umsikaba, *Drège s.n.* (?).

Apodynomene aemula E. Mey.: 113 (1836). *Tephrosia aemula* (E. Mey.) Harv. & Sond.: 210 (1862), pro parte. Type: E Cape, in graminosis inter Zandplaat et Komba, *Drège s.n.* (B, holo.).

Tephrosia triphylla Harms in O. Kuntze: 57 (1898). Type: Natal, Krantzklouf, *Kuntze s.n.* (NY, holo.—K, photo.!).

Tephrosia armitageana Chiov.: 421 (1908). Type: Natal, Port Natal, *Armitage* 547 (? Fl.).

Tephrosia spathacea sensu H. M. L. Forbes: 995 (1948), non Hutch. & Burt Davy: xxxi (1932).

Distribution: widespread in the eastern half of the Flora area.

Vouchers: *Compton* 27355 (K, PRE); *Huntley* 472 (K, NU); *Liebenberg* 7990 (K, PRE); *Mogg* 5812 (K, PRE); *Rogers* 18020 (K, PRE).

11a. var. *diffusa* (E. Mey.) B. D. Schrire, comb. et stat. nov.

Apodynomene diffusa E. Mey.: 113 (1836). *Tephrosia diffusa* (E. Mey.) Harv. in Harv. & Sond.: 210 (1862). Type: Transkei, in rupetris ad fluvium quendam minorem inter Umsamvubu et Umsikaba, *Drège s.n.* (K!).

Apodynomene aemula E. Mey.: 113 (1836). *Tephrosia aemula* (E. Mey.) Harv. in Harv. & Sond.: 210 (1862) pro parte. Type: E Cape, in graminosis inter Zandplaat et Komga, *Drège s.n.* (B, holo.).

Distribution: ecotypes within the range of the species.

Vouchers: *Acocks* 21940 (PRE); *Ross* 1886 (K, NH); *Strey* 6620 (K, PRE); *Venter* 7708 (PRE); *Wood* 886 (K).

Notes

(1) H. M. L. Forbes examined material in B before the Second World War for her revision (1948). She designated a specimen, *Drège* (*Herb. Meyer* 5471) as a type thus choosing one of the syntypes in Meyer's protologue as the lectotype. Since this material was destroyed and it is not clear which syntype she chose, a new lectotype can be designated from any of the original syntypes.

(2) The *T. macropoda* complex is a widespread group of trailing to prostrate open grassland herbs and over the

major part of its range, i.e. Transvaal and much of Natal, Transkei and the eastern Cape, it is easily recognizable as one species, *T. macropoda*. On the periphery of this range, however, there is considerable divergence from the typical form:

(a) Along the eastern coastal strip plants are particularly robust but are clearly recognizable as *T. macropoda*.

(b) In the following regions plants may be much reduced in size:

(i) the higher altitude foothills and slopes of the Drakensberg in Natal to Transkei;

(ii) the southerly end of the species range in the E Cape;

(iii) the coastal hinterland of Transkei and Natal;

(iv) parts of the E Transvaal and Swaziland.

(3) One distinct form (referred to here as var. *diffusa*) occurs in these areas, and is associated with edaphically dry granite or sandstone outcrops. Plants are procumbent, diffusely branching and often form dense mats. Typical *T. macropoda* may be found in the surrounding grassland and the two may appear to be quite separate taxa.

(4) *T. macropoda* is, however, a variable species and smaller-leaved forms do occur and will intergrade with the typical form, particularly at the extremes of its range and with increasing altitude. These are sometimes difficult to distinguish from the diffuse plant in the herbarium. The latter is clearly an ecotype and the name is retained as a variety of *T. macropoda* but doubtful plants should be retained in *T. macropoda* sensu lato.

12. ***Tephrosia brummittii* B. D. Schrire**, sp. nov. *T. macropodae* affinis, sed stipulis late ovatis, maturitate conspicue rubris vel brunneis, arcte appressis ad caules, foliis 7–11(–13)-foliolatis, foliolis anguste oblongo-ellipticis ad oblanceolatis differt.

TYPE.—Natal, 2832 (Mtubatuba): Hlabisa Distr., St Lucia Estuary Game Park, W of Vidal Rd (–AD), *Pooley* 1918e (NU, holo.; K, PRE, iso.).

Perennial spreading suffrutex up to 600 mm high, arising from a woody rootstock. *Stems* one to many, herbaceous except at the base, prostrate to ascending, glabrous or sparsely pubescent to ascending pilose, branching near the base. *Leaves* 7–11(–13)-foliolate, (30–) 70–120(–140) mm long; stipules (6–) 7–17 × 3–11 mm, broadly ovate, base often cordate, apex acuminate, maturing conspicuously red or brown, closely appressed to the stems; petiole (15–) 25–55(–70) mm long, canaliculate adaxially; leaflets (12–) 18–35(–42) × 3–7(–12) mm, narrowly oblong-elliptic or oblanceolate, base cuneate to rounded, apex emarginate, obtuse or acute, mucronate, upper surface green, glabrous or minutely puberulent, lower surface moderately appressed to spreading greyish pubescent. *Pseudoracemes* terminal and leaf-opposed, with 1–2(–3) flowers open at any one time. *Bracts* 5–15 × 4–10 mm, broadly ovate-acuminate, navicular, completely enclosing young buds, scarious, chestnut-brown, minutely bifid at the apex. *Flowers* 11–21 mm long. *Calyx* tube to 4 mm and teeth to 6 mm long, teeth lanceolate at the base narrowing to a long

attenuate apex, longer than the tube, sparsely to moderately pubescent with long spreading hairs on the teeth. *Standard* 11–21 mm long, to 20 mm wide, broadly obovate to orbicular, narrowing to a claw 2–3 mm long at the base, apex rounded or emarginate, dorsally densely pubescent, ventrally glabrous, scattered punctate-glandular as are all the petals. *Wings* 10–18 × 7 mm including a claw 2–3 mm long, cultrate with an auricle at the base of the lamina above the claw, sculpturing present, upper basal, up to 20 transcostal lamellae. *Keel petals* up to 18 × 7 mm including a claw 2–3 mm long. *Staminal sheath* 10–14 mm long, the stamens then free and alternating in length, 5 and 4 filaments to 4 and 3 mm long respectively, vexillary stamen to 17 mm long, free. *Ovary* to 16 mm long. *Style* to 8 mm long, curving erect from the ovary, flattened dorsiventrally and densely pubescent on both surfaces. *Stigma* capitate. *Fruits* immature, glabrous. *Seeds* 10–16, transversely arranged.

SWAZILAND.—2631 (Mbabane): Umbuluzi Falls near stream (–AD), *Compton* 25094 (NBG, PRE).

NATAL.—2732 (Ubombo): Lebombo Mountains, Gwalaweni Forest (–AC), *Brenan* 14272 (K, PRE); Umpangazi Lake (–DA), *Strey* 5097 (NH, PRE). 2831 (Nkandla): Mtunzini Distr., 15 miles NW of Port Durnford (–DD), *Codd & Dyer* 2826 (K, PRE). 2832 (Mtubatuba): Hlabisa Distr., St Lucia Estuary Game Park, W of Vidal Rd (–AD), *Pooley* 1918e (K, NU, PRE).

This species has often been confused with *T. macropoda* var. *macropoda*, from which it differs by having stipules maturing conspicuously red or brown and remaining closely appressed to the stems, and leaves 7–11 (–13)-foliolate with leaflets narrowly oblong-elliptic to oblanceolate. *T. macropoda* var. *macropoda* is distinguished by having stipules maturing dark brown and curling away from the stems, and leaves 3–7-foliolate with leaflets obovate to narrowly obovate or elliptic.

T. brummitti occurs sympatrically with *T. macropoda* and, although a few problem plants occur in overlapping areas, e.g. *Huntley* 194 (PRE) from Mtunzini, Natal, they are not readily identifiable as intermediates.

Two specimens from southern Mozambique, cited by Brummitt: 372 (1968) as *T. incarnata*, also belong to this species. These are: 1, Sabie, Lebombo Mountains, Meponduine, *Pedro & Pedrogao* 735 (LMJ); 2, Namaacha, near the Canada Dry factory, *Barbosa & Lemos* 7534 (COI, LISC, LMJ). Both localities are near the border with Swaziland in the Lebombo Mountains.

The plants grow at altitudes from 0–450 m in the coastal and lowveld vegetation types of N Zululand, S Mozambique and E Swaziland. These prostrate herbs occur in open grassland from coastal dunes to stream-banks and forest margins along the Lebombo Mountains.

This species is named in honour of Dr R. K. Brummitt of the Royal Botanic Gardens, Kew, who has contributed much to the knowledge of the genus *Tephrosia* from the *Flora Zambesiaca* area.

13. *Tephrosia albissima* H.M.L. Forbes in *Bothalia* 4: 995 (1948). Type: Natal, Greytown, *Wylie s.n.* (NH21590) (NH, holo.!, K!, PRE!).

13a. subsp. *albissima*.

Tephrosia galpinii H. M. L. Forbes: 996 (1948). Type: Natal, Greytown, on railway bank on town commonage, *Galpin* 14755 (PRE, holo.!, NH!).

Distribution: Natal midlands to Transkei.

Vouchers: *Schrire* 298, 312, 831 (NH); *Stirton* 5598 (K, PRE); *Wylie s.n.* (NH37157) (NH).

13b. subsp. *zuluensis* (H. M. L. Forbes) B. D. Schrire, comb. et stat. nov. *Tephrosia zuluensis* H. M. L. Forbes in *Bothalia* 4: 997 (1948). Type: Natal, Nkandhla, *Wylie s.n.* (NH9399) (NH, holo.!).

Tephrosia unifolia H. M. L. Forbes in *Bothalia* 4: 996 (1948). Type: Natal, W Zululand, *Baker s.n.* (NH19781) (NH, holo.!).

Distribution: W Zululand and N Natal.

Vouchers: *Codd* 6987 (K, NH); *Grobbelaar* 801 (PRE); *Ngwenya* 31 (NH); *Schrire* 2216 (NH); *Turner* 1 (NH).

Notes

(1) *T. albissima* is another variable complex including a number of names published simultaneously by H. M. L. Forbes (1948). A geographically distinct segregate, *T. zuluensis* is given subspecific status and this includes those forms from western Zululand and northern Natal which have almost sessile leaves and very reduced densely pilose leaf rachides. This creates problems in the choice of key characters because the typical subspecies becomes very much reduced in size at the opposite end of its range in the higher altitude areas of Kokstad and Harding in eastern Griqualand (following a similar trend to *T. macropoda* sensu lato.).

(2) Another entity, *T. unifolia* H. M. L. Forbes is placed in synonymy under subsp. *zuluensis* but further field study is needed to be certain of its position. The best example is *J. Turner* 1 (NH) from the Babanango Distr. in western Zululand. The leaves are distinctly petiolate with leaflets narrowly oblong-elliptic to oblanceolate, both longer and narrower than typical subsp. *zuluensis*. The collections *Brown & Shapiro* 73 (K) from Itala Nature Reserve and *Ross* 1741 (PRE) from near Goedegun in the Louwsberg, need further investigation as they appear to be somewhat intermediate between *T. albissima* and *T. macropoda* sensu lato.

14. *Tephrosia gobensis* Brummitt in *Boletim da Sociedade Broteriana*, sér. 2, 41: 368 (1968). Type: Mozambique, Goba Distr., *De Sousa* 132 (LISC, holo.; PRE!).

Distribution: E Swaziland.

Vouchers: *Compton* 31915 (PRE) *Culverwell* 463 (K, PRE).

15. *Tephrosia bachmannii* Harms in *Botanische Jahrbücher* 26: 286 (1899). Type: Transkei, Pondoland, *Bachmann* 616 (B, holo.).

Distribution: N Transkei and S Natal.

Vouchers: *Crawford* 390 (K, PRE); *Strey* 9591 (K, NH); *Wood* 3021, 3101 (K).

Notes

This species is very variable, with three distinct forms:

(a) procumbent grassland suffrutices e.g. *Shackleton* 367 (KEI);

(b) low woody bushes with linear-oblanceolate leaflets, from exposed rocky areas e.g. *Acocks* 13375 (PRE);

(c) woody subshrubs up to 2 m high with broader, obovate leaflets conspicuously white sericeous abaxially, e.g. *Sidey* 4185 (PRE).

Further investigation is needed to assess this variation.

16. *Tephrosia grandiflora* (Ait.) Pers., Synopsis Plantarum 2: 329 (1807). Types: Cape, Hort. Kew 1777, seed from C. B. S., *Masson s.n.* (BM, syn.); *Africa australis*, *Masson s.n.* (BM, syn.).

Galega grandiflora Ait.: 70 (1789).

Distribution: SW Cape to S Natal.

Vouchers: *Bruce* 453 (K, PRE); *Marais* 1195 (K, PRE); *Stirton* 6297; 6320 (K, PRE); *Strey* 6897 (K, NH, PRE).

Notes

The largest and most difficult complex, which is allied to both *T. albissima* and *T. macropoda* sensu lato, comprises those erect or bushy subshrubs related to *T. grandiflora* (species 14 to 21). *T. grandiflora* has traditionally been confused with many of the species in this group but presents no problems itself. The isolated *T. gobensis* from the Lebombo region seems most closely allied to it as does the endemic *T. bachmannii* from the sandstone outcrop areas of northern Pondoland/southern Natal.

17. *Tephrosia inandensis* H. M. L. Forbes in *Bothalia* 4: 276 (1948). Type: Natal, Inanda Distr., *Wood* 289 (NH, holo.; K!).

Distribution: Eshowe to Inanda Districts of Natal.

Vouchers: *Forbes* 108 (NH); *J. P. Forbes s.n.* (NH); *Lawn* 537 (NH) *Rogers* 24018 (PRE); *Stirton* 5341 (NH).

Note

T. inandensis is closely allied to *T. glomeruliflora* (no. 18), and *Schrire* 330 (NH) from the Natal coastal area adjacent to Eshowe is a hybrid between them.

18. *Tephrosia glomeruliflora* Meisn. in Hooker's London Journal of Botany 2: 86 (1843). Type: Natal, Port Natal, *Gueinzus s.n.* (K, holo.).

18a. subsp. *glomeruliflora*.

Distribution: Natal coastal belt and adjacent midlands.

Vouchers: *Baijnath* 145 (K, NU); *Grobbelaar* 1814 (K, PRE); *Nichols* 840 (NH); *Pole Evans* 3647 (K, PRE); *Wood* 11400 (NH).

18b. subsp. *meisneri* (Hutch. & Burtt Davy) B. D. *Schrire*, comb. et stat. nov. *Tephrosia meisneri* Hutch. & Burtt Davy: xxxi & 377 (1932). Type: Transvaal, *Sanderson s.n.* (K, holo.).

Tephrosia incarnata Brummitt: 370 (1968). Type: Zimbabwe, Umtali Distr., Himalayas, Engwa, *Wild* 4450 (SRGH, holo.; K!, PRE!).

Distribution: E half of Transvaal, N Natal to Natal midlands. It also extends northwards into Zimbabwe.

Vouchers: *Brenan* 14116 (K, PRE); *Germishuizen* 2852 (PRE); *Killian* 14 (PRE); *Nichols* 508 (NH); *Pole Evans s.n.* (PRE); *Strey* 7968 (NH).

Notes

(1) The glomerulose inflorescences and geographical distribution of the two taxa *T. glomeruliflora* and *T. meisneri* suggest one species with two distinct subspecies, and *Strey* 8371 (K, NH) from Ismont near Pietermaritzburg and *Coleman* 973 (NH) from Byrne in the Natal midlands indicate a possible transition from one to the other.

(2) The typical subspecies shows considerable variation in bract size. Some individuals have minute bracts not at all obscuring the young buds in the inflorescence (as in the type of the species). The bulk, though, have bracts enclosing the young buds completely. There is little evidence of intermediates between them and on further investigation the latter may warrant varietal status.

(3) A few plants of subsp. *meisneri* are depauperate e.g. *Meeuse* 9797 (K) from the Soutpansberg and *Galpin* 14451 (K) from Pilgrim's Rest. These require further investigation as mentioned under the next species.

19. *Tephrosia cordata* Hutch. & Burtt Davy in Burtt Davy, Flowering plants and ferns of the Transvaal 2: xxxi (1932). Type: Swaziland, Mbabane, *Burtt Davy* 2886 (K, holo.; BM!, PRE!).

Distribution: E Transvaal and Swaziland.

Vouchers: *Codd* 8198 (K, PRE); *Compton* 23302, 29985 (K); *Elan-Puttick* 320 (K, PRE); *Stirton* 1768 (K, PRE).

Note

T. cordata requires further study in the field, particularly as regards variation in stipule size and possible links with *T. glomeruliflora* subsp. *meisneri*, e.g. *Galpin* 13134 (K) from Dullstroom and *Pole Evans* 4245 (K) from Hendriksdal (both in the E Transvaal).

20. *Tephrosia subulata* Hutch. & Burtt Davy in Burtt Davy, Flowering plants and ferns of the Transvaal 2: xxxi & 377 (1932). Type: Transvaal, Barberton Distr., Highland Creek, *Galpin* 843 (K, holo.; NH!, PRE!, SAM!).

Distribution: E Transvaal and Weza District in E Griqualand.

Vouchers: *Balsinhas* 3153 (K, PRE); *Stirton* 10388 (NH); *Thorncroft* 36 (PRE); *Van der Merwe* 247 (K, PRE); *Viljoen* 133 (K, PRE).

Note

T. subulata occurs sympatrically with *T. cordata* in the E Transvaal, and *Kluge* 2347 (PRE) from Kaapschehoop is an aberrant specimen that may represent a hybrid between them.

21. *Tephrosia shiluanensis* Schinz in Vierteljahresschrift der Naturforschenden Gesellschaft in Zürich 52: 423 (1907). Type: Transvaal, Soutpansberg Distr., Shiluwane, *Junod* 2355 (Z, holo.).

Tephrosia spathacea Hutch. & Burtt Davy in Burtt Davy: xxxi (1932). Type: Transvaal, Lydenburg Distr., *Wilms* 341 (K, holo.).

Tephrosia medleyi H. M. L. Forbes: 968 (1948). Type: Natal, Kranskop Distr., nr Greytown, *Wood* 5984 (NH, holo.).

Tephrosia wyliei H. M. L. Forbes: 991 (1948). Type: Natal, Elandskop Distr., Sevenfontein nr Boston, *Wylie s.n.* (NH7996) (NH, holo.!).

Distribution: E Transvaal, Natal to Transkei.

Vouchers: *Codd 6961* (PRE); *Collins 3266* (PRE); *Germishuizen 95* (K, PRE); *Junod 1106* (K, PRE); *Kluge 2253* (K, PRE); *Tyson 1434* (K).

Notes

(1) *T. shiluwanensis* is a variable species. At the western end of its range, i.e. from the Pietermaritzburg to Harding Districts, plants tend to be less robust with bracts generally more conspicuous and ovate-apiculate. This group matches the type of *T. wyliei* but for the most part they cannot reliably be separated from *T. shiluwanensis*.

(2) *Fakude 68* (PRE) is a hybrid with *T. glomeruliflora* **subsp.** *glomeruliflora* from the Hlabisa District of Natal.

(3) An aberrant specimen, *Evans 345* (NH) from the Umlaas District between Pietermaritzburg and Durban may be a hybrid with *T. inandensis* and requires further investigation.

(4) Two additional species have been recorded as introductions to southern Africa but there is no evidence that they have become naturalized:

(a) *T. candida* (Roxb.) DC.; *Roxburgh s.n.*, Cape of Good Hope ex Botanic Garden, Calcutta (K);

(b) *T. vogelii* Hook. f.; *Strey 9009*, Ntsubane, Transkei (NH, PRE).

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A new species and a new combination of *Asclepias* (Asclepiadaceae) in southern Africa

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Keywords: *Asclepias*, Asclepiadaceae, new combination, new species, southern Africa, taxonomy

ABSTRACT

A new species is described: *Asclepias gordon-grayae* A. Nicholas, sp. nov. and a new combination is made: *Asclepias compressidens* (N.E. Br.) A. Nicholas, comb. nov.

UITTREKSEL

'n Nuwe spesie word beskryf: *Asclepias gordon-grayae* A. Nicholas, sp. nov. en 'n nuwe kombinasie word gemaak: *Asclepias compressidens* (N.E.Br.) A. Nicholas, comb. nov.

1. *Asclepias gordon-grayae* A. Nicholas, sp. nov. *A. pateni* N.E. Br. et *A. praemorsae* Schltr. affinis; differt a *A. praemorsa* appendicibus antherae brevibus et a *A. pateni* margine supero coronae prope extremum distale fisso.

Herba perennis. *Caudex* profundus, lignosus. *Caulis* unicus, erectus, gracilis, pubescens. *Folia* expansa, anguste lanceolata ad linearia, 34–128 × 2,25–(–35) mm. *Inflorescentia* umbellata, ad nodos et terminalis, semi-pendens. *Flores* rosei ad eburnei. *Corolla* expansa usque ascendens, lobis ovatis, basi connatis. *Corona* cucullata-saccata, appendicibus proximalibus dentatis, subfalcatis, extremo distali coronae brevissimo et obtuso, sinus coronae saccati, carina coronae rotundata. *Appendices* antherae ovatae usque ellipticae, 1,0–1,4 × 0,5–1,0 mm. *Apex styli* truncatus. *Pollinia* hemitruclata usque hemipyriiformes, 0,68–0,92 × 0,40–0,52 mm. *Fructus* fusiformis, apice rostrato.

TYPE.—2832 (Mtubatuba): (–AB) Natal, Zululand, St Lucia, Eastern Shores State Forest, Simbonvini vlei, 20 m (65 ft) alt., March 1982, *Nicholas 1285* (PRE, holo.; CPF, K, NH, MO).

Perennial herb with woody, semi-swollen, deep-seated underground organs. *Stem* single, erect, 240–750 mm high. *Leaves* spreading, narrowly lanceolate to linear, occasionally upper leaves falcate, 34–128 × 2–25 (–35) mm, apex acute to acuminate, base minutely auriculate to minutely hastate; petiole 0,6–1,3 (–2,0) mm long. *Inflorescence* umbelliform, semipendulous, axillary and terminal, 1–4 per plant, 4–6 (–9)-flowered; peduncles 7–14 (–24) mm long. *Flowers* 6–14 × 4,5–8,0 mm, pink or pale pink to cream; pedicel 7–20 mm long. *Sepals* lanceolate, occasionally triangular or narrowly ovate, 2,2–3,4 × (0,7–)1,4–2,1 mm. *Corolla* spreading to ascending; petals connate at base, ovate, apex acute, 6,4–7,7 × 3,2–4,9 mm, white, cream or pink in centre and near apex, margins white to pale pink, abaxial surface glabrous, margins minutely scabrous. *Corona lobes* fused to staminal tube 0,3–0,5 mm above

corolla, saccate or cyathiform, 1,3–2,6 × 2,3–3,3 mm, white to cream with pink keel. Upper proximal ends extended into 2 long, dentate, subfalcate appendages 1,5–2,8 × 0,4–0,8 mm, level with style apex, 2 tooth- or wing-like flaps present below appendages on proximal margin. Upper margin oblique to style apex, proximal end usually higher than distal end, which is sometimes raised into a short, blunt projection deeply cleft at apex, cleft running a short distance along rounded keel. *Staminal column* 2–3 mm high; alar fissure 1,2–2,0 mm long; anther wings curvirostrate, 1,2–2,0 × 0,5–0,9 mm; anther appendages ovate to elliptic, 1,0–1,4 × 0,5–1,0 mm, membranous, white, decumbent on style apex. *Style apex* truncate, 1,5–3,0 mm wide. *Pollinia* hemitruclloid to hemipyriiform, 0,68–0,92 × 0,5–0,52 mm; translator arms 0,2–0,32 mm long; corpusculum 0,28–0,4 × 0,5–0,52 mm. *Fruits* fusiform, ±65 × ±10 mm, puberulous. Figure 1.

NATAL.—2831 (Nkandla): Ngoye Forest Reserve (–DC), *Gordon-Gray 6191* (NU), *Hilliard 2699* (NH, NU), *Huntley 624* (NU), *Nicholas 1074* (NU), *Stewart 2155* (NU), *Stirton 466* (PRE), *Strey 6106* (NH, NU), *Wood 5678* (NH), 10823 (BOL, SAM), 2832 (Mtubatuba): St Lucia (–AB), *Cawood 141* (CPF), *Nicholas 1285* (CPF, K, MO, NH, PRE); St Lucia (–AD), *Crundall s.n.* (PRE 51584), *Pooley 1819* (NU), 2930 (Stanger): Gingindlovu (–BA), *Wood 10828* (SAM).

*Asclepias gordon-grayae*** is endemic to coastal Zululand where it grows in boggy situations. This species has been named in honour of Professor K. D. Gordon-Gray who has collected extensively (particularly in Natal) and who for many years lectured in taxonomy at the University of Natal, Pietermaritzburg. Professor Gordon-Gray has through her many publications and her teaching of taxonomy made a positive contribution to the knowledge of the southern African flora. *A. gordon-grayae* has in the past been confused with *A. patens* N.E.Br. with which it has many affinities. Vegetatively

** In Nicholas (1982) the manuscript name *A. gracilicaulis* was used (in reference to the long, thin, wavy stem of this species). This name was never validly published and has been dropped here in favour of the name *A. gordon-grayae*.

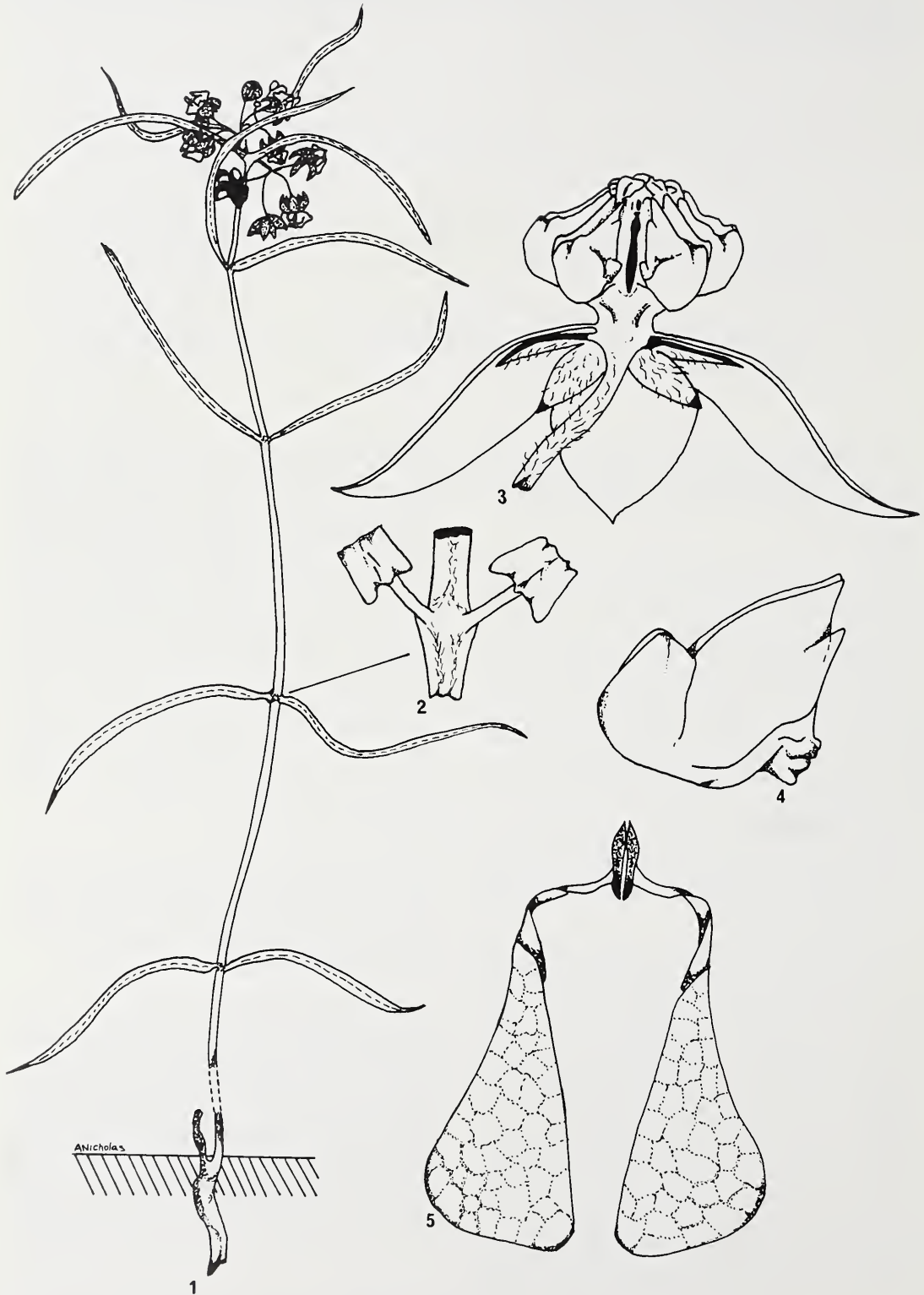


FIGURE 1.—*Asclepias gordon-grayae*. 1, flowering plant, $\times 0.25$, Edwards s.n. (BOL); 2, node showing bifariously arranged hairs and leaf bases, $\times 4$, Gordon-Gray 6191 (NU); 3, flower, $\times 7$, Stewart 2155 (NU); 4, corona lobe, side view, $\times 3$, Stewart 2155 (NU); 5, pollinarium, $\times 130$, Stewart 2155 (NU).

tell these two species apart. However, there are marked differences in flower colour, corona lobe size and shape, anther appendage size and shape and pollinia width (Figure 2; Table 1). There are also differences in distribution (Figure 3) and in habitat preference. The number, degree and consistency of these and other differences are diagnostically important and help separate *A. gordon-grayae* from its two closest relatives: *A. patens* and *A. praemorsa* Schltr. (Figures 2, 4 & 5; Table 1). *A. gordon-grayae* may be found growing at altitudes between 30

and 900 metres and flowers between September and April, with a peak period in December.

KEY TO ASCLEPIAS GORDON-GRAYAE AND ITS CLOSEST ALLIES

- 1a Anther appendages $1,7-2,5 \times 1,0-1,6$ mm *A. praemorsa*
 1b Anther appendages $0,5-1,4 \times 0,5-1,0$ mm:
 2a Upper coronal edge entire; southern Natal and Transkei ..
 *A. patens*
 2b Upper coronal edge cleft near the distal end; Zululand
 only *A. gordon-grayae*

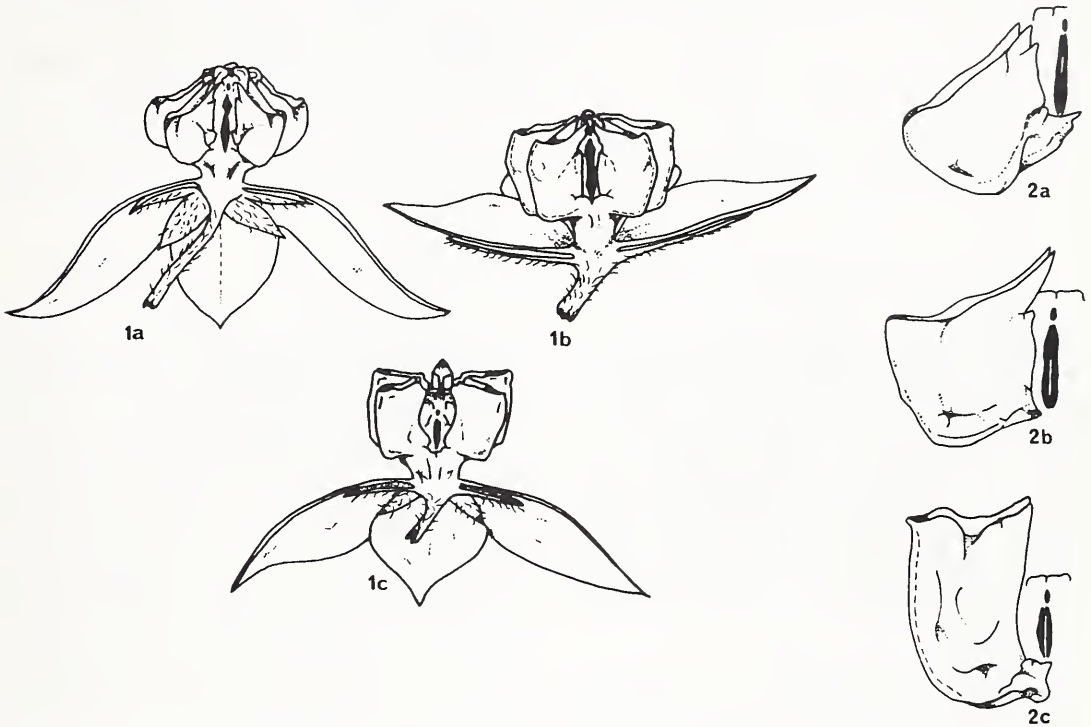


FIGURE 2.—A comparison of the flowers of: 1a, *Asclepias gordon-grayae*, $\times 5$, Stewart 2155 (NU); 1b, *A. patens* $\times 9,5$, Moss 470 (J); 1c, *A. praemorsa* $\times 8$, Strey 6902 (NH). A comparison of the corona lobes of: 2a, *A. gordon-grayae*, $\times 4$, Strey 6106 (NU); 2b, *A. patens* $\times 10$, Gordon-Gray 961 (NU); 2c, *A. praemorsa* $\times 14$, Wood 1162 (NH).

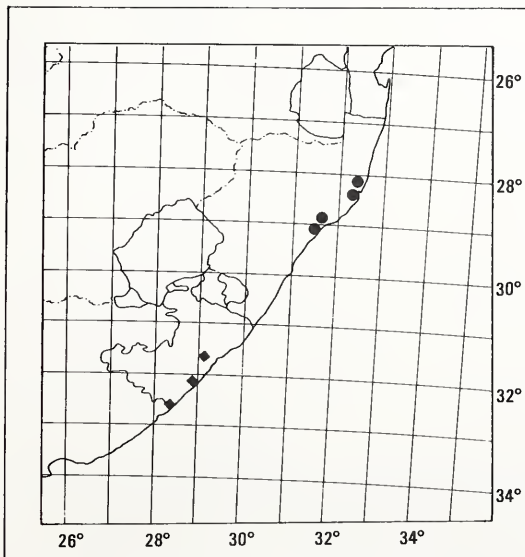


FIGURE 3.—Map showing comparative distribution of *Asclepias gordon-grayae*, ● and *A. patens*, ◆.

2. *Asclepias compressidens* (N.E.Br.) A. Nicholson, comb. et stat. nov.

Asclepias navicularis (E. Mey.) Schltr. var. *compressidens* N.E.Br.: 683 (1908). Type: Cape, 3225 (Somerset East): Cradock (—BA), Cooper 1284 (K, lecto!; PRE!).

Perennial herb with woody, swollen, deep-seated underground organ. Stems 1–6 per plant, decumbent. Leaves spreading to ascending, linear, occasionally narrowly lanceolate or falcate, $15-85 \times (1,5-2,0-4,5$ mm, apex acuminate, base petiolate, occasionally trullate, margins slightly revolute; petiole $1,5-3,0$ mm long. Inflorescences umbelliform, terminal, solitary, erect, 1–3 per plant, 4–9-flowered; peduncles 27–35 mm long. Flowers $\pm 1 \times 1,1-1,4$ mm, pink to light grey. Sepals ascending, lobes lanceolate, $6,6-6,8 \times 1,2-2,0$ mm. Corolla ascending, petals lanceolate to ovate, connate at base, $10,5-11,8 \times \pm 5$ mm, margins slightly revolute, occasionally sinuate, central vein prominent, colour inside lilac-green, outside purple-green, abaxial surface glabrous, adaxial surface canescent. Corona lobes arising from base of staminal column, erect, cucullate, saccate, $3,8-4,2 \times 1,7-2,0$ mm, upper proximal ends forming two obtuse almost triangular shoulders level with middle of anther-wings, proximal margins concave to

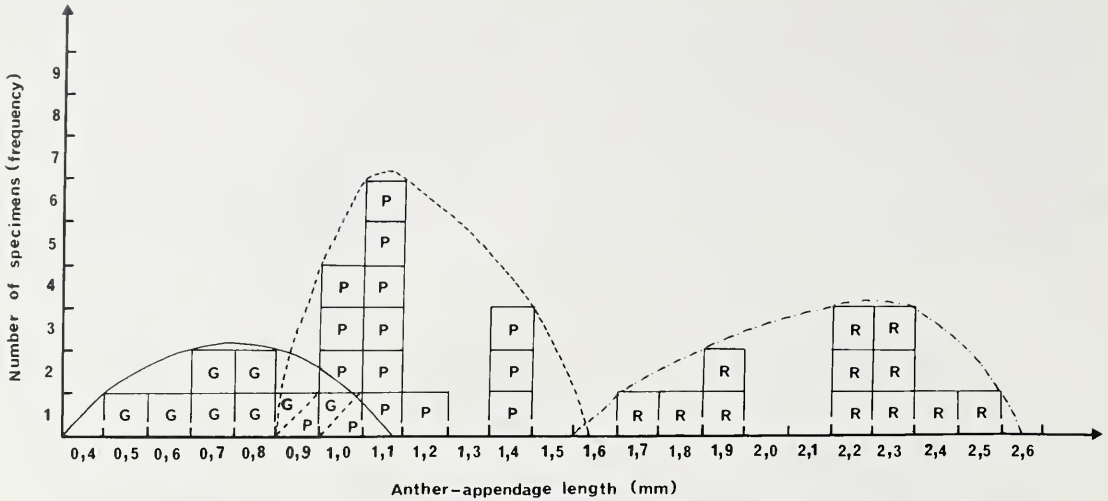


FIGURE 4.—Histogrammic comparison of anther appendage length in *Asclepias gordon-grayae*, G; *A. patens*, P; and *A. praemorsa*, R.

lobe base and folded to meet, upper margin entire, curving to form a deltoid, obtuse distal lobe end. Keel dipping near upper distal end, convex and narrow at lobe base. Sinus a narrow central channel, 3,8–4,2 mm long, with tongue-like appendage. *Staminal column* 3–4 mm long; alar fissure 1,7–1,8 mm long; anther-wings 1,7–1,8 × ± 0,7 mm, concave near apex with small notch on margin; anther appendages tongue-like, ovate, 1,0–1,3 × 1,1–1,2 mm, decumbent. *Style apex* truncated to slightly conical, 2,3–2,8 mm wide. *Pollinia* clavate to lacrimiform, 1,5–1,6 × ± 0,56 mm; translator arms 0,48–0,56 mm long; corpusculum 0,16–0,24 mm wide. Figure 6.

NATAL.—3126 (Queenstown): Queenstown (–DD), *Acocks 17936* (PRE). 3225 (Somerset East): Cradock (–BA), *Cooper 1284* (K, PRE). 3326 (Grahamstown): Alexandria (–CB), *Acocks 17872* (PRE); Southwell (–DA), *Bayliss 4631* (PRE). 3327 (Pieddie): near East London (–BB), *Wood 1995* (K).

Although closely allied to *Asclepias navicularis*, *A. compressidens* can be distinguished from it by a number of important characters (Figure 6; Table 2). Also *A. navicularis* has a distribution centred on the coastal region of the eastern Cape, whereas *A. compressidens* may also be found further inland (Figure 7) and at higher altitudes. The specific epithet refers to the compressed tongue-like appendage that lies within the corona lobe sinus. *A. compressidens* and *A. disparilis* N.E. Br. possess similar corona lobes, but in *A. disparilis* the distal corona lobe appendage is slightly elongated and there is a transverse shelf-like flap of tissue within the coronal sinus just above the middle point of the lobe; the leaves are also shorter and broader (Table 3). *A. compressidens* is found at an altitude of between 30 to 140 metres and flowers from November to February. It is found growing in grassland and is said to be rare.

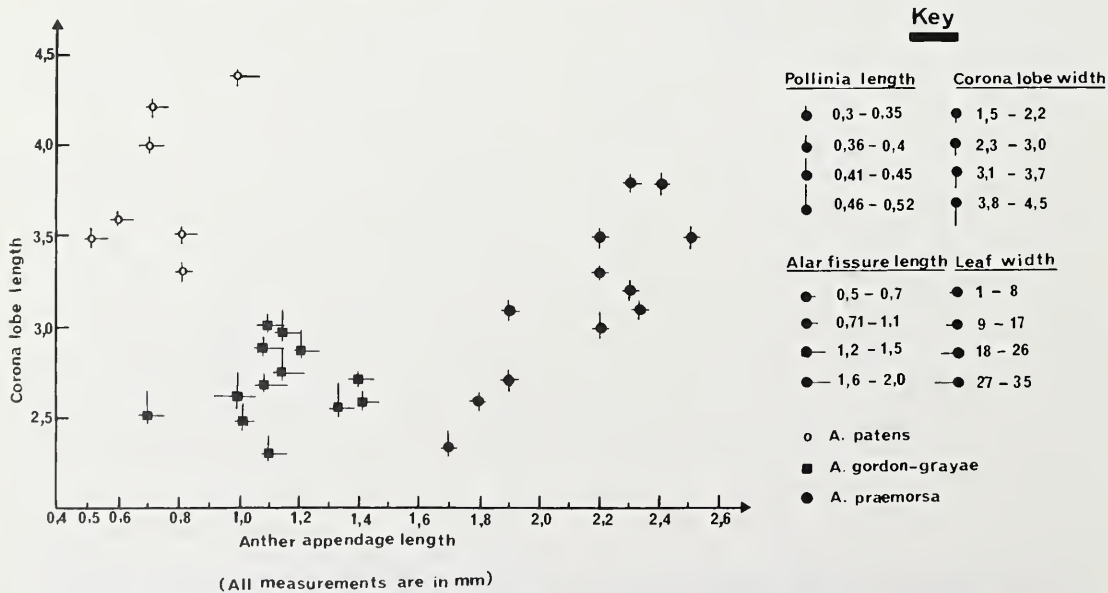


FIGURE 5.—Scatter diagram: a comparison of a number of characteristics in *Asclepias gordon-grayae*, *A. patens* and *A. praemorsa*.



FIGURE 6.—*Asclepias compressidens*. 1, flowering plant, $\times 0,6$, Acocks 17936 (PRE); 2b, flower, $\times 6,5$, Rogers 12762a (BOL); 3, pollinarium, $\times 120$, Rogers 1276a (BOL). A comparison of the flowers of: 2a, *A. navicularis* $\times 8$, Comins 1355 (PRE); 2b, *A. compressidens*, $\times 6,5$, Rogers 1276a (BOL).

TABLE 1.—A comparison of the differences separating *Asclepias gordon-grayae*, *A. patens* and *A. praemorsa*

Character	<i>A. gordon-grayae</i>	<i>A. patens</i>	<i>A. praemorsa</i>
Leaf width	2–25(–35) mm	1–9(–11) mm	1–3 mm
Corona lobe upper margin	May have a distinct dip near the distal end oblique to the style apex	Entire, undulating, slightly oblique to the style apex	Entire, truncated, level with the style apex
Corona: relationship to style apex	Proximal appendages tooth-like reaching, but not projecting over, the style apex	Proximal appendages tooth-like, projecting over the style apex	No true proximal appendages, corona higher than the style apex, but not projecting over it
Corona lobe (height)	1,3–2,6 mm	2,4–3,4 mm	2,2–3,8 mm
Corona lobe (width)	2,3–3,3 mm	3,0–4,4 mm	1,8–2,8 mm
Alar fissure (length)	1,2–2 mm	1,0–1,7 mm	0,6–1,1 mm
Anther appendage (shape)	Ovate to elliptic	Triangular to widely ovate	Oblong or strap-like
Anther appendage (length)	1,0–1,4 mm	0,5–1 mm	1,7–2,5 mm
Pollinia (length)	0,68–0,92 mm	0,8–0,92 mm	0,56–0,68 mm
Pollinia (width)	0,4–0,52 mm	0,32–0,4 mm	0,32–0,48 mm
Habitat	Mountain plateau marsh lands and boggy vleis	Grasslands on mountain slopes	Mountain grasslands on Table Mountain sandstone
Distribution	Zululand–Ngoye to St Lucia	Transkei–Kentani to Port St Johns	Transkei and southern Natal–Umtata to Pinetown

TABLE 2.—The main diagnostic differences between *Asclepias compressidens* and *A. navicularis*

Character	<i>A. compressidens</i>	<i>A. navicularis</i>
Corona lobe shape		
Level of corona lobe in relation to the style apex	Shorter than the style apex	Level with the style apex
Proximal corona lobe end in relation to the distal end	Lower than the distal end of the lobe	Level with the distal end of the lobe
Corona lobe sinus	Tongue-like flap inside	Transverse flap-like shelf inside
Anther-wing (outer edge)	Squared	Round
Notch on anther-wing margin	Near the top	Near the base
Pollinia	Claviform or lacrimiform	± Rectangular

TABLE 3.—The main diagnostic differences found between *Asclepias compressidens* and *A. disparilis*

Character	<i>A. compressidens</i>	<i>A. disparilis</i>
Leaf length	15–18 mm	12–37 mm
Leaf width	2–4,5 mm	3–9 mm
Distal appendage of corona lobe	Not produced	Slightly produced
Corona lobe sinus	Tongue-like projection	Transverse shelf-like flap

KEY TO ASCLEPIAS COMPRESSIDENS AND ITS CLOSEST ALLIES

- 1a Corona lobe sinus without transverse flap of tissue near apex, compressed tongue-like appendage present *A. compressidens*
- 1b Corona lobe sinus with transverse flap of tissue near apex, no compressed tongue-like appendage present:
 - 2a Upper distal corona lobe edge level with style apex; leaf width at lamina base 1–5 mm *A. navicularis*
 - 2b Upper distal corona lobe edge level with middle of anther-wing (not level with style apex) leaf width at lamina base 3–9 mm *A. disparilis*

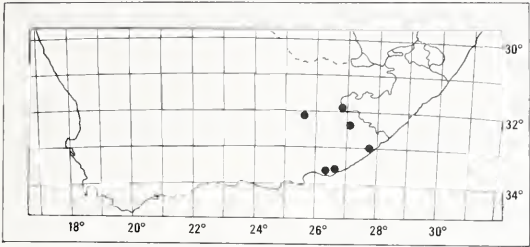


FIGURE 7.—Distribution of *Asclepias compressidens*.

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I would like to thank the Directors and staff of the following herbaria: BOL, CPF, GRA, J, K, NBG, NH, NU, P, PRE, RUH, SAM and TCD for the loan of her-

barium specimens; the Director and staff of the Department of Environment Affairs and the Head and staff of the Department of Botany, University of Natal, Pietermaritzburg who made facilities available to me for the study; Mr M. Lambert, Department of Classical Civilization, University of Natal, Pietermaritzburg for help with the Latin description of *Asclepias gordon-grayae*.

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Two new brown subcrustose *Parmelia* species from southern Africa (lichenized Ascomycetes)

F. BRUSSE*

Keywords: new species, lichenized Ascomycetes, *Parmelia*, southern Africa, subcrustose, taxonomy

ABSTRACT

Two new brown subcrustose species of *Parmelia* (Lichenes) are described from southern Africa on rock. They are *P. barda* Brusse and *P. princeps* Brusse. The affinities of the two species are discussed.

UITTREKSEL

Twee nuwe bruin halfkorsagtige *Parmelia*-spesies (Lichenes) is op klippe uit suidelike Afrika beskryf. Die nuwe spesies is *P. barda* Brusse en *P. princeps* Brusse. Die verwantskappe van die twee spesies word bespreek.

Parmelia barda Brusse, sp. nov.

Thallus subcrustosus, saxicola, usque ad 50 mm diametro. *Lobi* elongati, 0,2–0,7 mm lati, usque ad 1,5 mm longi, 75–100 μ m crassi. *Thallus superne* brunneus, nitidus, isidiis sorediisque nullis. *Cortex superior* 7–17 μ m crassus, anticlinare prosoplectenchymatus, epicortice poroso (Figure 2). *Stratum gonidiale* 10–35 μ m crassum, fasciculatum, algis *Trebouxiae*, 5–22 μ m diametro. *Medulla* alba, 20–80 μ m crassa. *Cortex inferior* hyalinus, paraplectenchymatus, 9–13 μ m crassus. *Thallus inferne* pallidus. *Rhizinae* non bene evolutae. *Apothecia* sessilia, numerosa, usque ad 0,8 mm diametro. *Hypothecium* hyalinum, 15–30 μ m crassum. *Subhymenium* 10–15 μ m crassum. *Hymenium* 44–55 μ m altum, J+ caeruleum. *Asci* clavati, poricidales, cum tholis J+

caeruleis (Figure 3). *Ascospores* octonae, hyalinae, simplices, ellipsoideae, 7–10 $\times$ 4,0–4,5 μ m. *Pycnidia* globosa, hyalina, circa 120 μ m diametro. *Pycnidiospores* hyalinae, aciculares, 7–10 $\times$ 0,8 μ m. *Thallus atranorium* ($\pm$) et materiam ignotam continens.

TYPE.—Cape, 3320 (Montagu): 4 km SW of Montagu, Kogmans Kloof near the old British Fort of 1899, on top of an E-W ridge, on Table Mountain Sandstone outcrops, alt. 200–250 m (–CC), Brusse 3718, 1981.05.12 (PRE, holo.). Figure 1.

Thallus subcrustose, saxicolous, up to 50 mm diam. *Lobes* elongate, 0,2–0,7 mm broad, up to 1,5 mm long, 75–100 μ m thick. *Upper surface* brown, non-isidiate and non-sorediate. *Upper cortex* 7–17 μ m thick, anticli-

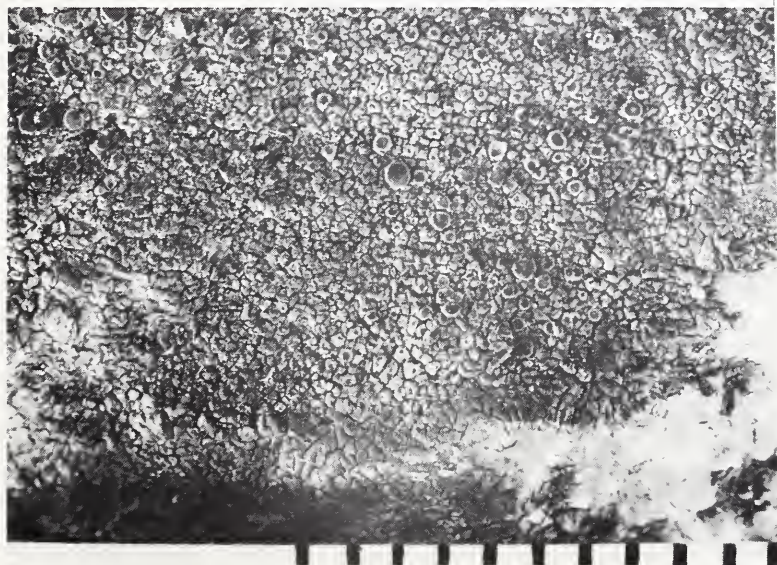


FIGURE 1.—*Parmelia barda*, habit. Brusse 3718, holotype. Scale in mm.

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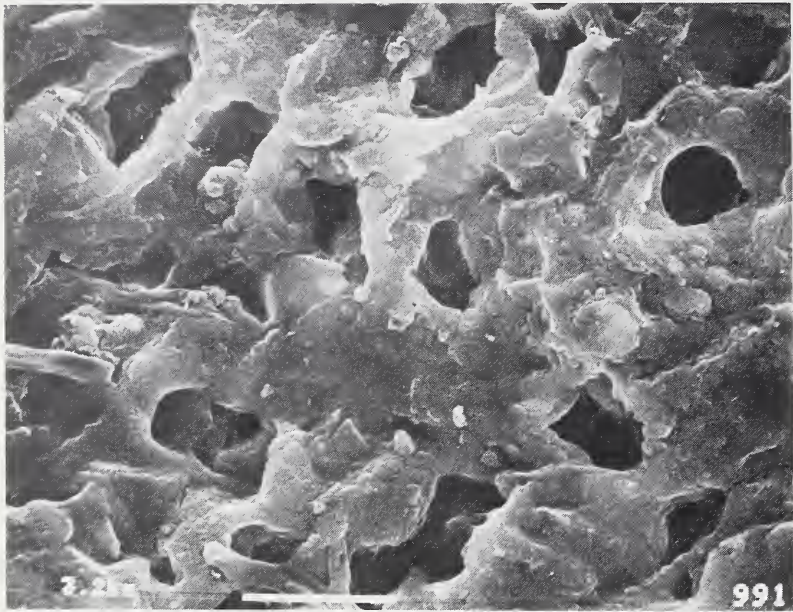


FIGURE 2.—*Parmelia barda*, SEM of upper surface. *Brusse 3718*, holotype. Bar = 6,3 μ m.

nally prosoplectenchymatous, epicortex pored (Figure 2). *Algal layer* clustered, clusters mainly subcortical, but also scattered in the medulla, 10–35 μ m thick, algae *Trebouxia*, 5–22 μ m diam. *Medulla* white, 20–80 μ m thick. *Lower cortex* hyaline, paraplectenchymatous, 9–13 μ m thick. *Lower surface* pale. *Rhizines* not well developed. *Apothecia* sessile, numerous, up to 0,8 mm across. *Hypothecium* hyaline, 15–30 μ m thick. *Subhymenium* 10–15 μ m thick. *Hymenium* 45–55 μ m high, J+ blue. *Asci* clavate, 8-spored, poricidal, tholus J+ blue (Figure 3). *Ascospores* hyaline, monolocular (but equatorial ‘plasma-bridges’ common), ellipsoid, 7–10 $\times$ 4,0–4,5 μ m. *Pycnidia* hyaline, globose, about 120 μ m diam. *Pycnidiospores* hyaline needles, 7–10 $\times$ 0,8 μ m. *Chemistry*: Atranorin ($\pm$) and an unidentified substance present (Table 1: bard-1).

TABLE 1.—TLC data for the two unidentified lichen substances, using norstictic acid and atranorin as standards (Culberson 1972)

Lichen substance	R_f class			$R_f \times 100$		
bard.-1	3	5	5–6	41/46,78	36/28,63	47/36,63
princ.-1	3	5	5–6	38/46,77	35/28,63	48/36,63

The rather narrow ascospores of this species are like those of the genus *Protoparmelia* Choisy. *Protoparmelia* differs from this species in many other respects even though it is also brown. The paraphyses are not capitate and capped, and the tholus iodine reaction differs significantly from *Protoparmelia*. At present the degree of tholus reaction variation is rather marked in *Parmelia*, but it is not yet clear how much variation there is within one species. If the iodine reaction pattern within the tholus proves to be consistent, one could use these patterns for generic segregation of the genus *Parmelia*, particularly if these correlate with the presently used thalline and chemical characters. The thallus anatomy of *Protoparmelia badia*, the type of *Protoparmelia* (Hafellner 1984) is also divergent from that of this new species. It was therefore thought best to place this species in the genus *Parmelia*. In fact the cortex reacts green with concen-

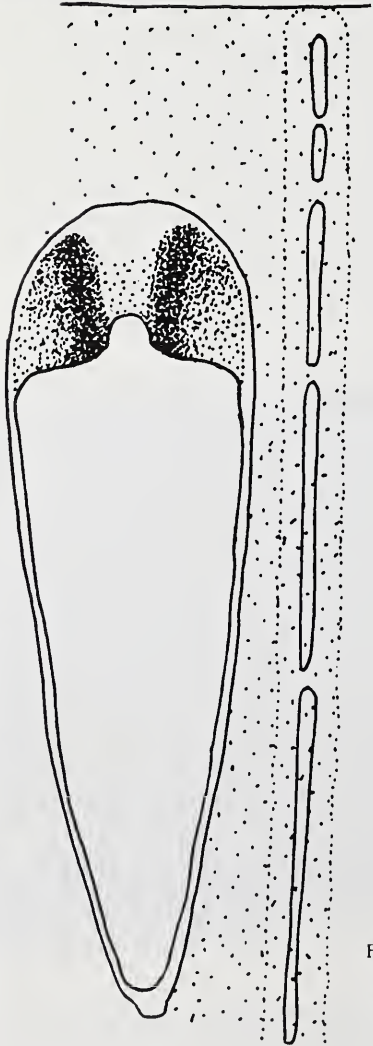


FIGURE 3.—*Parmelia barda*, ascus and paraphysis. *Brusse 3718*, holotype. Bar = 10 μ m.



FIGURE 4.—*Parmelia princeps*, habit. Brusse 3074, holotype. Scale in mm.

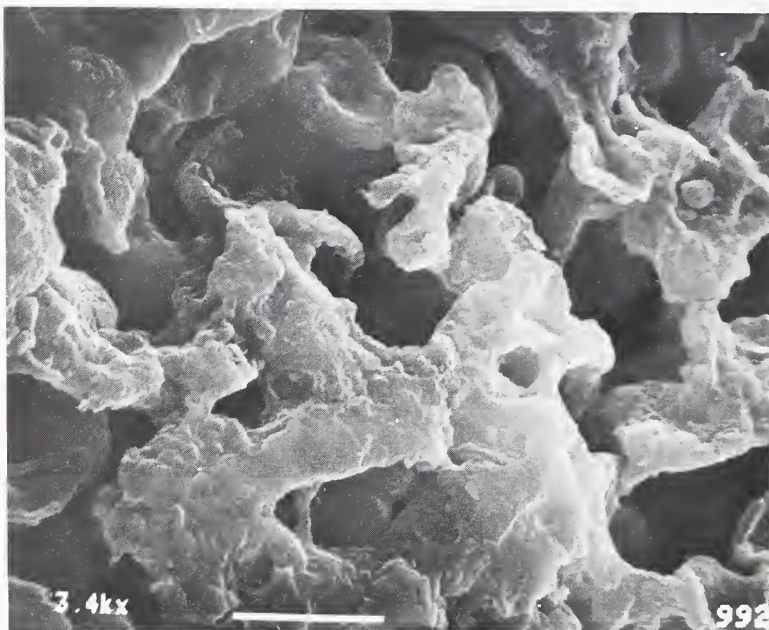


FIGURE 5.—*Parmelia princeps*, SEM of upper surface. Brusse 3074, holotype. Bar = 5,9 μ m.

trated nitric acid, and can be considered a small subcrustose member of the *Neofuscae* (Esslinger 1977), despite the additional presence of atranorin. *P. barda* was tested twice for chemical contents, the second run revealed no atranorin. The type specimen is growing on a rock with two micro-aspects and this may explain this difference. More exposed positions usually support specimens with a greater quantity of a particular lichen substance.

Although the substance in the medulla was not identified further, the spot characteristics indicated that it may be an orcinol *para*-depside. The R_f data for 'bard-1' are similar to those given for loxodellic acid (Esslinger 1977, p.19), but this could not be confirmed by direct comparison, for lack of a lichen at PRE containing loxodellic acid, or a confirmatory test such as a micro-crystal test (no published data). Nevertheless all the known subcrustose species of the section *Neofusca* contain depsi-

dones, with the exception of the New Zealand endemic, *P. minuta* Essl. which contains gyrophoric acid (Esslinger 1977).

At present this species is known only from the type specimen from Kogmans Kloof near Montagu.

Parmelia princeps Brusse, sp. nov.

Thallus subcrustosus, saxicola, usque ad 25 mm diametro. *Lobi* elongati, 0,1–0,3 lati, usque ad 1 mm longi, 80–95 μ m crassi. *Thallus superne* atro-brunneus, nitidus, isidiis sorediisque destitutus. *Cortex superior* 7–10 μ m crassus, epicortice poroso (Figure 5). *Stratum gonidiale* 15–35 μ m crassum, algis *Trebouxiae*, 5–18 μ m diametro. *Medulla* alba, 20–45 μ m crassa. *Cortex inferior* paraplectenchymatus, circa 15 μ m crassus, brunneus. *Thallus inferne* piceus. *Rhizinae* non bene

evolutae. *Apothecia* sessilia, rara, usque ad 0,5 mm diametro. *Hypothecium* hyalinum, 30–33 μm crassum, paraplectenchymatum, cellulis 3,5–7,5 μm diametro. *Subhymenium* 30–45 μm crassum. *Hymenium* hyalinum, 50–60 μm altum, J+ caeruleum. *Asci* clavati, poricidales, cum tholis J+ caeruleis (Figure 6). *Ascospores* hyalinae, simplices, ellipsoideae, 9,5–12,5 $\times$ 5,0–6,0 μm . *Pycnidia* non visa. *Thallus* acidum squamaticum continens.

TYPE.—Cape, 3218 (Clanwilliam), 3 km W of Olyvenboskraal, Witelskloof, on large Table Mountain Sandstone boulder-outcrop, alt. 450–500 m (–BD), *F. Brusse* 3074, 1981.05.02 (PRE, holotype). Figure 4.

Thallus subcrustose, saxicolous, up to 25 mm across. Lobes elongate, 0,1–0,3 mm broad, up to 1 mm long, 80–95 μm thick. Upper surface dark brown, glossy, non-isidiate and non-sorediate. Upper cortex 7–10 μm thick, epicortex pored (Figure 5). Algal layer 15–35 μm thick, algae *Trebouxia*, 5–18 μm diam. Medulla white, 20–45 μm thick. Lower cortex paraplectenchymatous, around 15 μm thick, brown. Lower surface black. Rhizines not well developed. *Apothecia* sessile, rare, up to 0,5 mm across. *Hypothecium* hyaline, 30–33 μm thick, paraplectenchymatous, cells 3,5–7,5 μm diam. *Subhymenium* 30–45 μm thick. *Hymenium* hyaline, 50–60 μm high, J+ blue. *Asci* clavate, poricidal, tholus J+ blue (Figure 6). *Ascospores* hyaline, monolocular, ellipsoid, 9,5–12,5 $\times$ 5,0–6,0 μm . *Pycnidia* not seen. Chemistry: cortical substances absent, squamatic acid and an unidentified substance (Table 1: princ.-1) in the medulla.

Parmelia princeps is another brown lichen that is not assignable to *Protoparmelia* Choisy, presently used for the *Lecanora badia* group, due to important structural differences (see the discussion of the previous species for these). The cortex of this species does not react with concentrated nitric acid (nor with 2 molar potassium hydroxide solution), but could probably still be assigned to the *Neofuscae*, as some members of this group are negative with concentrated nitric acid (Esslinger 1977). The only other subcrustose species containing squamatic acid is *Parmelia squamatica* Brusse (1980, 1986) but this is yellow-green coloured, with usnic acid in the upper cortex.

Parmelia princeps is presently known only from the type locality south-west of Clanwilliam.

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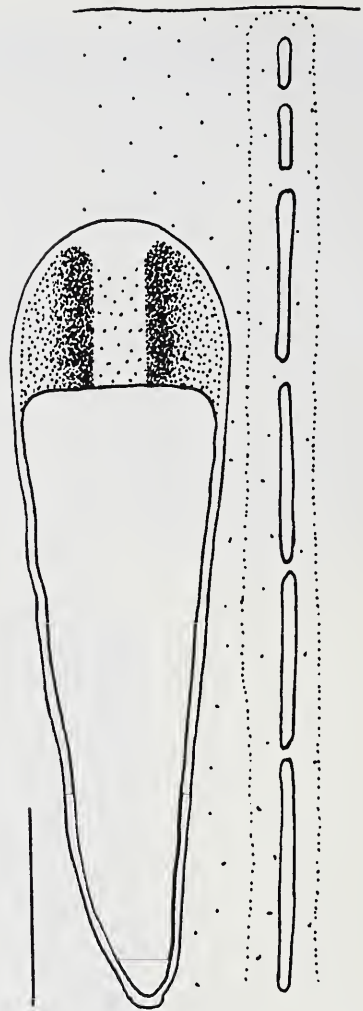


FIGURE 6.—*Parmelia princeps*, ascus and paraphysis. Brusse 3074, holotype. Bar = 10 μm .

Notes on African plants

VARIOUS AUTHORS

ASCLEPIADACEAE

NOTES ON ASCLEPIAS DIPLOGLOSSA, A. COGNATA AND A. FLAVA

A. flava N.E.Br. and *A. cognata* N.E.Br. have in the past been erroneously considered conspecific with *A. diploglossa* (Turcz.) Druce. Although allied, these three taxa are morphologically distinct.

South African herbaria have, for some years, treated *A. flava* N. E. Br. and *A. cognata* N.E.Br. as synonyms of the older *A. diploglossa* (Turcz.) Druce. This is due to the misinterpretation of a letter sent from Kew to the Botanical Research Institute in 1963. Marais, who was then the South African Liaison Officer at Kew, mentions in this letter that 'Mr Bullock regards both *A. flava* N.E.Br. and *A. cognata* N.E.Br. as conspecific with *A. diploglossa*'. He does, however, state earlier in the same

letter 'As far as I know *A. flava* N.E.Br. has not been sunk under *A. diploglossa*'. This was, and still is the case as Bullock did not publish his opinions. Despite Marais's warning that these reductions to synonymy were not validly published, Bullock's suggestions were unfortunately followed and to all intents and purposes *A. flava* and *A. cognata* became synonyms under *A. diploglossa*. This situation has recently been rectified in Gibbs Russell *et al.* (1984) and further details are given here.

Although vegetatively similar, close examination shows all three species to be distinct taxonomic entities with very different floral morphologies (Figures 1 & 2; Table 1).

KEY TO ASCLEPIAS DIPLOGLOSSA AND ITS ALLIES

- 1a Proximal corona lobe appendages projecting over style apex *A. cognata*
- 1b Proximal corona lobe appendages not projecting over style apex:
 - 2a Corona lobes with arm-like proximal appendages crossing over each other and reflexing back into coronal sinus, appendages are below style apex and level with anther-wings *A. flava*
 - 2b Corona lobes without true proximal appendages, proximal ends of corona forming dentate to obtuse (but protruding) shoulders level with top of style apex *A. diploglossa*

Representative specimens

Asclepias diploglossa (Turcz.) Druce

NATAL.—2730 (Vryheid): Wakkerstroom (–AD), *Devenish* 759 (NH, PRE). 2828 (Bethlehem): Royal Natal Park (–DB), *Acocks & Hafstrom* 11205 (PRE). 2829 (Harrismith): Van Reenen (–AD), *Wood* 11205 (PRE). 2929 (Underberg): Giants' Castle (–AB), *Symons* 188 (PRE); Highmoor State Forest (–BC), *Killick & Vahrmeijer* 3583 (PRE); Sani Pass (–CB), *Lugillies* 109 (NU); Bushman's Nek (–CC), *Killick & Vahrmeijer* 3969 (PRE); Garden Castle Nature Reserve (–CD), *Hilliard & Burt* 7866 (NU); Mpendle (–DB), *Moll* 1481 (PRE); Glengarriff (–DD), *Rennie* 488 (NU). 2930 (Pietmaritzburg): Greytown (–BA), *Wylie s.n.* (NH 21644); Inanda (–DB), *Groom s.n.* (NH 4106).

TRANSKEI.—3028 (Matatiele): Ramatselisio's Gate (–BB), *Boardman* 186 (PRE).

CAPE.—3227 (Stutterheim): Hogsback (–CA), *Compton* 1421 (NBG); Dohne Hill (–CB), *Sim* 1237 (SAM). 3326 (Grahamstown): near Grahamstown (–BC), *Glass* 1503 (SAM).

Asclepias flava N.E.Br.

NATAL.—2929 (Underberg): Underberg (–CD), *Dyer* 3744 (NH); Sunset (–DA), *Rennie* 275 (NU); Mpendle (–DB), *Huntley* 625 (NH); Nkonzo State Forest (–DD), *Nicholas & Norris* 1159 (CPF, NH, PRE). 2930 (Pietmaritzburg): Howick (–AC), *Haygarth s.n.* (SAM 8378); Blinkwater Range (–AD), *Nicholas* 1019 (NU); Zwaartkop (–CB), *Wood* 11219 (SAM); Byrne (–CC), *Stewart* 2023 (NU); Dargle (–DB), *Nicholas & George* 1040 (CPF, K, MO, NH, NU). 3030 (Port Shepstone): Ixopo (–AA), *Shirley s.n.* (NU).

TRANSKEI.—3029 (Kokstad): Mt Currie (–AD), *Tyson* 1686 (BOL, PRE); Malowe (–BD), *Tyson* 1086 (BOL, SAM); Vaal Bank (–CB), *Haygarth s.n.* (NH 4230); Ngeli Forest (–DA), *Coleman* 813 (PRE); Fort Donald (–DC), *Tyson* 1660 (SAM). 3128 (Umtata): Bazija (–CB), *Baur* 556 (SAM).

CAPE.—3326 (Grahamstown): Grahamstown (–BC), *Glass* 1503 (NBG).

Asclepias cognata N.E.Br.

NATAL.—2929 (Underberg): Fort Nottingham (–BD), *Hilliard & Burt* 9056 (NU); Bamboo Mountain (–CB), *Grice s.n.* (NU); Garden Castle Nature Reserve (–CD), *Hilliard & Burt* 13767 (NU); Mpendle (–DB), *Hilliard & Burt* 13856 (NU).

TRANSKEI.—3029 (Kokstad): Ensikeni (–BA), *Haygarth s.n.* (NH 15735); Mount Insizwa (–CD), *Schlechter* 6496 (BOL, NH); Ngeli Mountain (–DA), *Hilliard & Burt* 5769 (NH, NU).

CONCLUSIONS

A. flava and *A. cognata* have never been validly reduced to synonymy under *A. diploglossa* and are, as outlined by Brown (1908), distinct species allied to, but separable from *A. diploglossa*.

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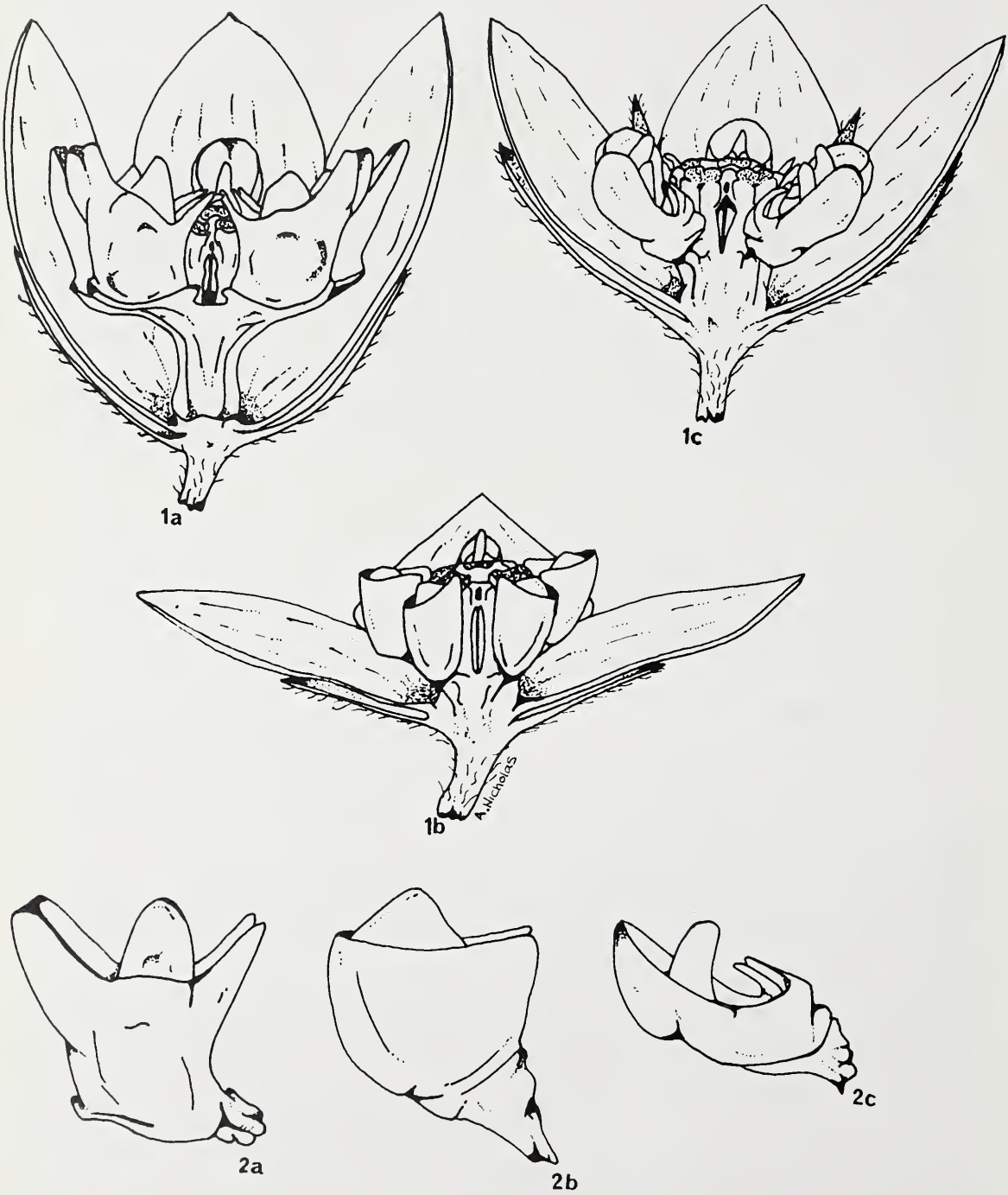


FIGURE 1.—Comparison of flower (1) and corona lobe (2) of *Asclepias* species. Structure in: 1a, *A. cognata*, $\times 10$, Hilliard & Burt 9056 (NU); 1b, *A. diploglossa*, $\times 20$, Boardman A11 (PRE); 1c, *A. flava*, $\times 19$, Coleman 813 (PRE); 2a, *A. cognata*, $\times 17$, Hilliard & Burt 9056 (NU); 2b, *A. diploglossa*, $\times 28$, Boardman A11 (PRE); 2c, *A. flava*, $\times 38$, Coleman 813 (PRE).

TABLE 1.—A comparison of *Asclepias cognata*, *A. diploglossa* and *A. flava*. All measures in mm

Character	<i>A. cognata</i>	<i>A. diploglossa</i>	<i>A. flava</i>
Leaf length	7–68	5–133	7–83
Petiole length	0–3	0–4	0–5
Inflorescence bract length	2,6–6,2	2,5–10	2,6–7,5
Peduncle length	3–92	0–95	4–175
Flower colour	Yellow, yellow & purple	Yellow, yellow & brown	Yellow-green
Flower width	7–17	6–13	5–8
Flower height	5–12	4–9	3–6
Sepal width	1–1,8	1–1,5	0,7–1,2
Petal length	5,8–10,5	4–7	3,5–5
Petal width	2,6–5,8	2,4–4,1	2–3,2
Corona lobe shape	Bonnet-like	Cup-like	Bowl-like
Corona lobe (sinus depth)	2,2–2,5	1,1–2	0,4–0,7
Proximal corona lobe appendage length	0,6–1,2	None	0,25–0,7
Coronal sinus appendage length	0,8–1,3	0,2–0,7	0,4–0,7
Alar fissure length	0,8–1,4	0,75–1,1	0,5–0,7
Anther appendage width	0,8–1,3	0,6–0,9	0,5–0,8
Style apex width	1,5–2,8	1,1–2,1	1,1–1,6
Translator-arm length	0,32–0,56	0,2–0,36	0,18–0,28
Corpusculum length	0,2–0,3	0,22–0,32	0,16–0,26
Pollinium length	0,72–0,96	0,68–0,84	0,48–0,68
Pollinium width	0,24–0,32	0,24–0,36	0,16–0,24

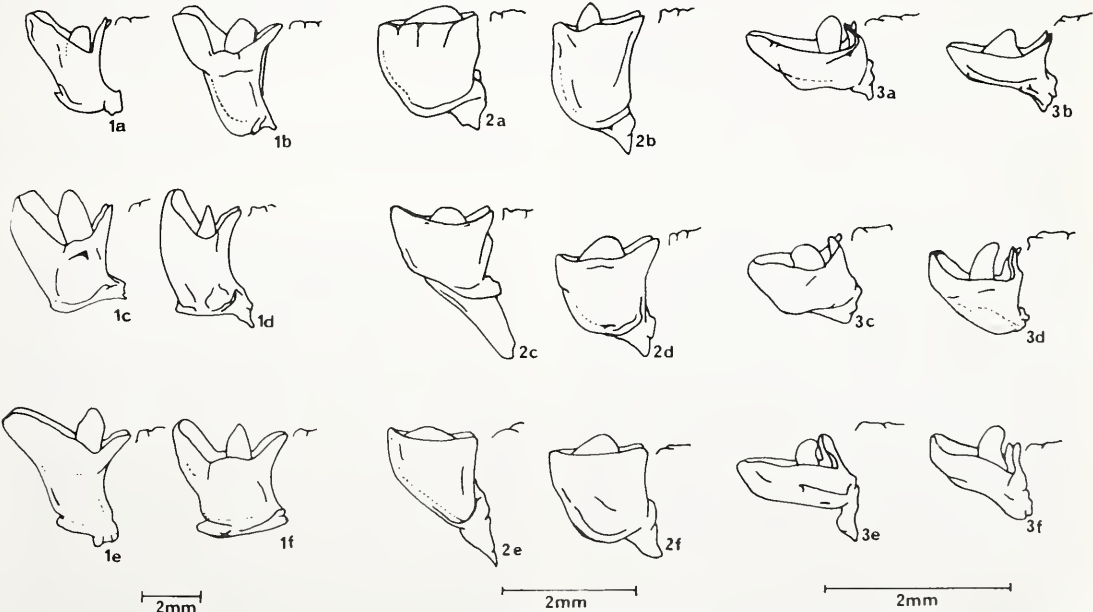


FIGURE 2.—A comparison of corona lobe variation. 1, *Asclepias cognata*: a, Hilliard & Burt 5769 (NH); b, Haygarth s.n. (NH 13661); c, Hilliard & Burt 13452 (NU); d, Hilliard & Burt 13767 (NU); e, Haygarth s.n. (NH 15735); f, Hilliard & Burt 13856 (NU). 2, *A. diploglossa*: a, Grice s.n. (NU); b, Wylie s.n. (NH 21644); c, Devenish 759 (PRE); d, Rennie 488 (NU); e, Wood 11205 (PRE); f, Barker 1421 (NBG). 3, *A. flava*: a, Hilliard & Burt 5839 (NU); b, Baur 556 (SAM); c, Glass 1503 (NBG); d, Tyson 1660 (SAM); e, Tyson 1686 (BOL); f, Wood 11219 (SAM).

of Botany, University of Natal, Pietermaritzburg; and the Director and staff of the Department of Environment Affairs.

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A. NICHOLAS

ERYSIPHACEAE

TWO NEW *Oidium* SPECIES FROM THE TRANSVAAL

In January 1985 an *Oidium* species was observed on leaves of *Dombeya rotundifolia* (Hochst.) Planch. in the garden of the Botanical Research Institute, Brummeria, Pretoria. The fungus was observed until leaf drop but no teleomorph was produced. The only previous report of an *Oidium* sp. occurring on a *Dombeya* sp. is from Natal in the Camperdown area of Pietermaritzburg, viz. on *D. cymosa* Harv. (Doidge 1950). However, this fungus was not described and, although the fungus on both *Dombeya* species is likely to be the same, this cannot be stated for certain. As no fresh material of the Natal fungus could be obtained it is absolutely necessary to have a detailed description of the Transvaal fungus available for future comparison. The fungus from *D. rotundifolia* is therefore, described here in detail.

A few months later at the same venue an *Oidium* species was observed on *Lannea discolor* (Sond.) Engl. at the end of its growing season. Quite a number of powdery mildew fungi have been observed on Anacardiaceae, the plant family to which *Lannea* spp. belong. Apart from two *Phyllactinia* spp., one *Uncinula* sp., a *Sphaerotheca* sp., two *Erysiphe* spp. and one *Macrosphaera* sp. which have been recorded (Hirata 1966), two *Oidium* spp. have been described, viz. *O. anacardii* Noack (1898) and *O. mangiferae* Berthet (1914).

Identity of our *Oidium* species with *Sphaerotheca macularis* (Wallr. ex Fries) Magnus and *Erysiphe cichoracearum* DC. can be excluded immediately on account of the solitary production of conidia in the *Lannea* fungus, while *Phyllactinia* spp. do not have an *Oidium* stage. Moreover, no imperfect stage has apparently been observed for *Uncinula verniciferae* P. Henn. (Salmon 1905). Identity with *Microsphaera alni* (Wallr.) Winter, *Erysiphe communis* (Wallr.) Link and *Oidium mangiferae* must also be excluded on account of the flexuous or bent foot cells of the conidiophores. This leaves *O. anacardii* which has conidia similar in size and shape to the *Lannea* fungus. However, its description by Noack (1898) does not mention whether the foot cells of the conidiophores are straight or flexuous. In addition the presence or absence and shape of appressoria and fibrosin bodies is also not recorded. This and the apparent absence of *Oidium anacardii* from the African continent, as well as the fact that the *Lannea* fungus occurs on a previously unrecorded host of powdery mildew, makes it desirable to describe this fungus as a new species.

Oidium dombeyae Gorter & Eicker, sp. nov.

Mycelium superficiale, albidum, effusum. *Hyphae* hyalinae, subflexuosae, aliquando geniculatae. Cellulae hypharum, 35–45 × 4–5 µm. *Appressoria* non lobata vel moderate lobata. *Conidiophora* cylindracea (70–

90–115(–130) × 7,5–10 µm, plerumque 2-septata. Cellulae basales rectae, comparate longae, (50–)65–90 (–110) × 7,5–10 µm; cellulae sequentes breviores, (7,5–)12,5(–17,5) × 7,5–10 µm. *Conidia* ovoidea, solitaria, (22,5–)27,5–30(–35) × (15–)17,5(–20) µm. Corpuscula fibrosina conspicue desunt. Ratio longitudinis/latitudinis conidiorum circa 1,6. Tubi germinationis, apicales vel subapicales, plerumque perbreves, interdum autem longiores, 12,5–125 × 2,5–5,0 µm, saepe in appressorium non lobatum vel modice lobatum (7,5–15 × 5,0–7,5 µm) terminantes.

Habitat in foliis vivis *Dombeyae rotundifoliae* (Hochst.) Planch., Brummeria, Pretoria. Ianuarius 1985, PREM No. 47848.

Mycelium superficiale, white, thinly spread. *Hyphae* hyaline, slightly flexuous, sometimes geniculate. Hyphal cells, 35–45 × 4–5 µm. *Appressoria* unlobed or moderately lobed. *Conidiophores* cylindrical, (70–)90–115(–130) × 7,5–10 µm, usually 2-septate. Foot cells straight, comparatively long, (50–)65–90(–110) × 7,5–10 µm, followed by one or more shorter cells (7,5–)12,5(–17,5) × 7,5–10 µm. *Conidia* singly produced, ovoid, (22,5–)27,5–30(–35) × (15–)17,5(–20) µm; length/width ratio ± 1,6. Germ tubes near end of conidia, apical or subapical, usually very short but sometimes longer, 12,5–125 × 5,0–7,5 µm, often ending in an unlobed or moderately lobed appressorium (7,5–15 × 5,0–7,5 µm).

On leaves of *Dombeya rotundifolia* (Hochst.) Planch., Pretoria Botanical Garden, Brummeria. January 1985, PREM No. 47848.

Oidium lanneae Gorter & Eicker, sp. nov.

Mycelium amphigenum, griseo-albidum, effusum vel densum. *Hyphae* plus minusvae rectae, aliquando flexuosae vel geniculatae, rectangulariter ramificatae saepe prope septum. Cellulae hypharum (37,5–)50–60 (–70) × 5,0–6,2 µm. *Appressoria* moderate lobata vel multilobata, aliquando binatim opposita. *Conidiophora* numerosa, brevia, (1–)3(–4)-cellularia (30–)50–75 (–110) × (7,5–)8,7–11,2 µm, saepe ab basi ad apicem leviter dilatentia. Cellulae basales geniculatae, flexuosae vel curvatae, raro rectae, (25–)35–55(–90) × 7,5–10 µm. *Conidia* solitaria, ellipsoidea vel oblonga, utrinque obtuse rotundata, (25–)30–35(–40) × (13,7–)15–17,5(–20) µm. Ratio longitudinis/latitudinis conidiorum circa 2. Corpuscula fibrosina conspicue desunt. Tubi germinationis prope apicem orientes, interdum apicales, circa recti, 50–75 × 3–4 µm, saepe in appressorium non lobatum vel modice lobatum 5,0–7,5 µm latum terminantes. Aliquando tubi perbreves remanentes ac in appressorium multilobatum terminantes.

Habitat in foliis vivis *Lanneae discoloris* (Sond.) Engl., Brummeria, Pretoria. Maius 1985, PREM Nos. 47877, 47974.

Mycelium amphigenous, greyish white, effuse to dense. *Hyphae* more or less straight, occasionally flexuous or geniculate, branching at right angles often near a septum. Hyphal cells (37,5–)50–60(–70) $\times$ 5–6,2 μ m. *Appressoria* moderately lobed or multilobed, sometimes opposite in pairs. *Conidiophores* numerous, short, (1–)3(–4)-celled, (30–)50–75(–110) $\times$ (7,5–)8,7–11,2 μ m, often slightly widening from base to top. Foot cells geniculate, flexuous or bent, seldom straight, (25–)35–55(–90) $\times$ 7,5–10 μ m. *Conidia* singly produced, ellipsoid to oblong, obtusely rounded at both ends, (25–)30–35(–40) $\times$ (13,7)15–17,5(–20) μ m; length/width ratio $\pm$ 2. No well developed fibrosin bodies are present. Germ tubes originate near end of conidia, usually apically, nearly straight, 50–75 $\times$ 3–4 μ m, often ending in an unlobed or moderately lobed appressorium, 5,0–7,5 μ m wide; tubes sometimes remain very short, ending in a multilobed appressorium.

On leaves of *Lannea discolor* (Sond.) Engl., Pretoria Botanical Garden, Brummeria. May 1985. PREM Nos. 47877, 47974.

Although referring and describing imperfect forms of ectophytic powdery mildews to the form genus *Oidium* does not find favour with some mycologists it is a necessary procedure in tropical and subtropical regions of the world where the teleomorph of many mildew fungi is seldom produced (Doidge 1915; Hansford 1946) and where powdery mildews in most cases can only be identified on the basis of anamorphic characters (Clare 1964; Boesewinkel 1977; Hammett 1977).

ACKNOWLEDGEMENTS

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FABACEAE

A NEW SPECIES OF *INDIGOFEA* FROM NATAL AND TRANSKEI

Indigofera rubroglandulosa Germishuizen, sp. nov., *I. hiliaris* Eckl. & Zeyh. similis sed dense tecta pilis glandulosis, etiam lobis calycis longioribus, foliolis latioribus atque caudice globoso tuberoso differt.

TYPE.—Natal, 3030 (Port Shepstone): Margate (–CD), *Strey 10990* (PRE, holo. !; NH, iso. !). Figure 3.

Small erect to semi-erect herb up to 0,3 m tall arising from a woody base; rootstock tuberous, globose. *Stems* reddish brown, longitudinally ridged, with scattered biramous hairs densely interspersed with red glandular hairs or occasionally with only few scattered biramous hairs. *Stipules* free, adnate to base of petiole, up to 7 mm long, glandular on outside, glabrous inside. *Leaves* regular, paripinnate, petiolate. *Leaflets* 3–7, obovate to narrowly elliptic to oblanceolate, (7–)12,5–17(–20) $\times$ (3,5–)5–9(–11) mm, stiffly mucronate at apex, obtuse at base, strigillose on both surfaces with biramous hairs, red glandular-hairy on lower surface only and along mar-

gins. *Petiole* up to 4 mm long. *Inflorescence* axillary, racemose, 4–10-flowered, up to 40 mm long, including a 10–20 mm long peduncle, covered with both biramous and red glandular hairs. *Flowers* deep pink to red, 8–9 mm long, each subtended by a lanceolate caducous bract 2–3 mm long. *Calyx*: tube 2 mm long, lobes 3,5–6 mm long, glabrous inside, outside with both biramous and glandular hairs. *Standard* 7–9 $\times$ 5–7,5 mm, broadly ovate, narrowing to base, mucronate at apex, strigose outside, glabrous inside. *Wing petals* 8 $\times$ 2 mm. *Keel blades* 8–9 $\times$ 2–2,5 mm, prominently pocketed; pockets more or less triangular, up to 2 mm long. *Style* 7 mm long, upcurved for about 2 mm, white-strigose for two-thirds of its length; stigma capitate. *Stamens* 5–7 mm long; 9 fused into a staminal sheath and the 1 vexillar stamen free; anthers uniform, 1 mm long, strongly apiculate; apiculum up to 0,5 mm long. *Fruit* a cylindrical pod, 20–25 mm long, up to 3 mm in diameter, reddish brown, white-strigose interspersed with red glandular hairs. *Seeds* 1,5 mm long and wide.

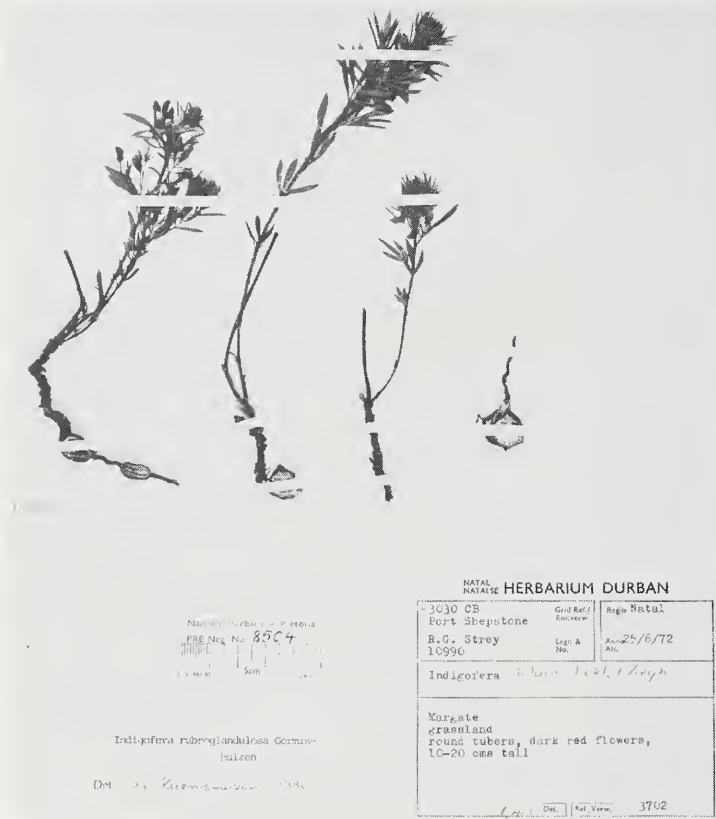


FIGURE 3.—Holotype of *Indigofera rubroglandulosa* Germishuizen (Strey 10990).

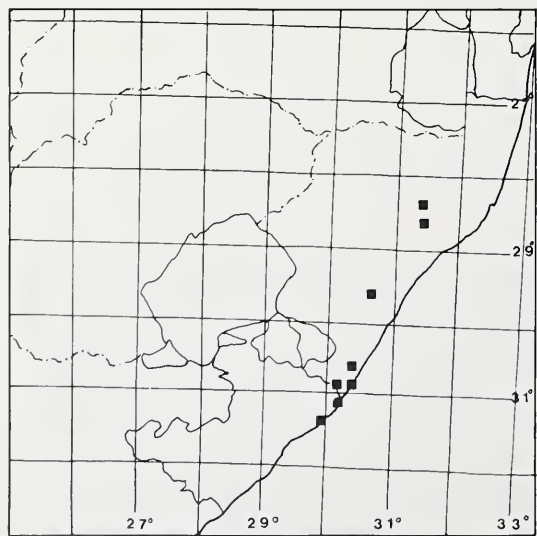


FIGURE 4.—Distribution of *Indigofera rubroglandulosa*.

NATAL.—2831 (Nkandla): 6 km south of Mtonjaneni on road to Melmoth (—AD), *Codd 1803*; Melmoth (—CB), *Bellmarley s.n.* 2930 (Pietermaritzburg); Camperdown (—DA), *Moll 1886*. 3030 (Port Shepstone): Oribi Gorge, 'Fairacres' (—CB), *Van Wyk 5127*; Umtamvuna Nature Reserve (—CC), *Abbott 223*; Izingolweni-Port Edward road (—CC), *Ward 185*; Margate (—CD), *Strey 10990*; Uvongo Bantu

Location 5 (—CD), *Strey 8729*; Uvongo (—CD), *Stirton 8057*. 3130 (Port Edward): Beacon Hill (—AA), *Strey 6510*.

TRANSKEI.—3129 (Port St Johns): Mkambati Game Reserve (—BD), *Shackelton 89*; 5 km from Mkambati on road to Mtontsasa (—BD), *Van Wyk 1531*; Mkambati Leper Institute, along road from hospital to office (—BD), *Marais 1170*; 3 km from Mkambati hospital (—BD), *Venter 829*.

I. rubroglandulosa is found in Natal and Transkei (Figure 4) in grassland recently burnt. The first record of the species in the PRE Herbarium was collected by *H. W. Bellmarley s.n.* (PRE 58841), during July 1927 from Melmoth. It flowers in late winter to early summer. All the material cited above was incorrectly identified as *I. hilaris* or as *Indigofera* species. Although the distribution areas of *I. hilaris* and *I. rubroglandulosa* overlap, the latter can be distinguished from the former by its longer calyx lobes, wider leaflets and the red glandular hairs. With the aid of a scatter diagram (Figure 5) using calyx length along one axis and width of leaflets along the other axis, *I. hilaris* and *I. rubroglandulosa* are readily separated.

ACKNOWLEDGEMENTS

I would like to thank Dr H. F. Glen for translating the diagnosis into Latin.

G. GERMISHUIZEN

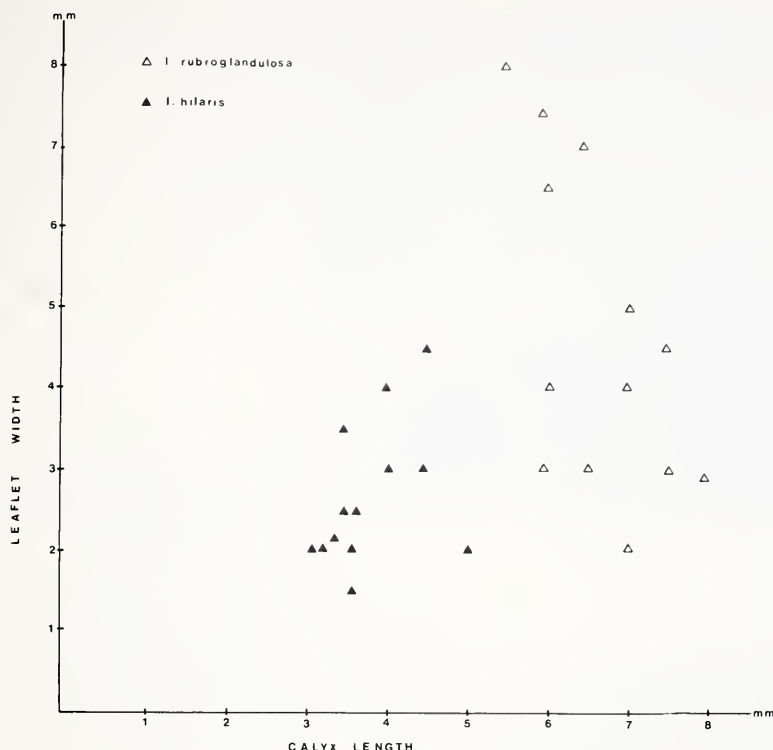


FIGURE 5.—Scatter diagram of calyx length and leaflet width of *Indigofera rubroglandulosa* and *I. hilaris*.

LICHINACEAE

A NEW SPECIES OF *GONOHYMENIA* FROM ETOSHA PAN LIMESTONE

Gonohymenia etoshica Brusse, sp. nov.

Thallus peltatus, calcicola, usque ad 3 mm diametro, madefactus 240–320 μ m crassus, homoeomerus. *Pagina superior* carbo-atra, hebetata, undulata vel cerebriformis, ambitu breve lobata. *Pagina inferior* carbo-atra, hebetata, laevis vel grosse et radiatim plicata. *Apothecia* immersa vel substipitata, lecanorina, thallinocarpa, usque ad 0,7 mm diametro. *Excipulum thallinum* in lateribus 70–150 μ m crassum. *Excipulum thallinum* in lateribus destitutum. *Hymenium* hyalinum, in dimidio superiori cum algis inspersum, 70 μ m altum, J+ caeruleum. *Hypothecium* tenue, fere nullum. *Paraphyses* graciles, simplices vel leviter ramosae (in regionibus algarum bene ramosae), luminibus 0,8–1,0 μ m crassis, septatae, gelatinosae, gelatina J+ caerulea. *Asci* obclavati, 8-, 12-vel 16-sporei, parietibus omnibus tenuibus, J–, 25–40 $\times$ 9–14 μ m. *Ascospores* hyalinae, ellipsoideae, 6–7 $\times$ 3,5–4,5 μ m, simplices. *Pycnidia* globosa, hyalina, circa 50 μ m diametro. *Spermatia* bacillaria, 2,8–3,6 $\times$ 0,8–1,0 μ m.

TYPE.—1916 (Gobaub): Etosha Pan, 28 km from Halali to Okaukuejo, Salvadoria, on littoral limestone outcrops—gentle N slope (–AB), Brusse 4155, 1984.03.19 (PRE, holo.; LD, iso.). Figure 6.

Thallus peltate, on limestone, up to 3 mm diam., homoeomerous, 240–320 μ m thick when wet (Figure 7). *Upper surface* charcoal, matt, undulate to cerebriform-

wrinkled, simple to shortly lobate at margins. *Lower surface* charcoal, matt, smooth to coarsely radiate plicate. *Apothecia* (Figure 8) immersed to substipitate, lecanorine, thallinocarpous, up to 0,7 mm diam. *Thalline exciple* 70–150 μ m thick on sides. *Exciple* hyaline, J–, 8–12 μ m thick, dense periclinial plectenchyma, absent from margins (Figure 8). *Hymenium* hyaline, interspersed with algae in upper half, 70 μ m high, J+ blue. *Hypothecium* thin, almost absent. *Paraphyses* slender, simple or lightly branched (well branched in algal areas), lumens 0,8–1,0 μ m thick, septate, gelatinized, gel J+ blue. *Asci* obclavate, 8-, 12- or 16-spored, walls thin, J– (Figure 9), 25–40 $\times$ 9–14 μ m. *Ascospores* hyaline, ellipsoid, 6–7 $\times$ 3,5–4,5 μ m, simple. *Pycnidia* hyaline, globose, about 50 μ m diam. *Spermatia* hyaline rods, 2,8–3,6 $\times$ 0,8–1,0 μ m.

This new species is most similar to the European species, *Gonohymenia nummularia* (Nyl.) Henss., but has smaller and fewer ascospores per ascus.

The number of algae in the upper half of the hymenium seems to vary considerably. Sometimes algae are quite scarce, e.g. in the specimen cited below, but the type is rich in hymenial algae. The asci of this species are obclavate with acute apices and with thin walls (no tholus development). However the hymenial gel is blue in Lugol's iodine solution. The asci containing 12 or 16 spores are larger than those containing only 8 ascospores, so that the ascospores from 8-spored asci are of the same overall size as those from 16-spored asci. It is

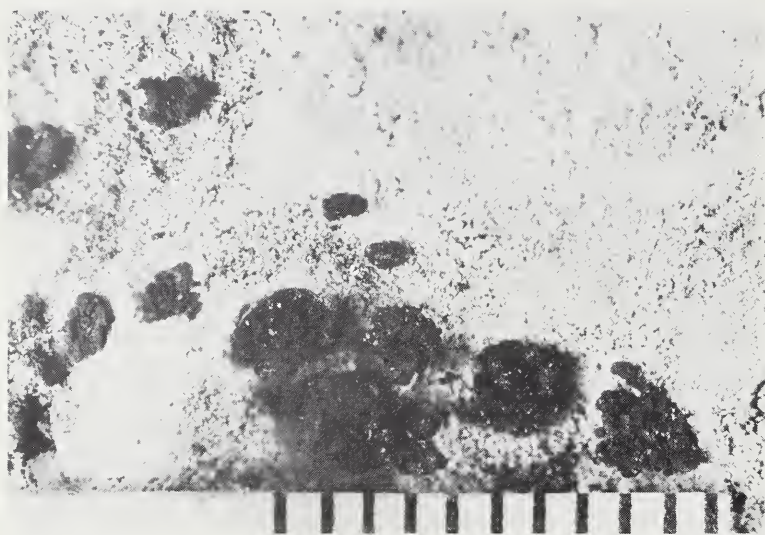


FIGURE 6.—*Gonohymenia etoshica* Brusse, habit. *Brusse 4155*, holotype. Scale in mm.



FIGURE 7.—*Gonohymenia etoshica* Brusse, edge of lobe section in lactophenol cotton-blue, showing undifferentiated hyphae anticlinal to the surface, and algal cells concentrated near the surface. *Brusse 4155*, holotype. Bar = 100 μ m.

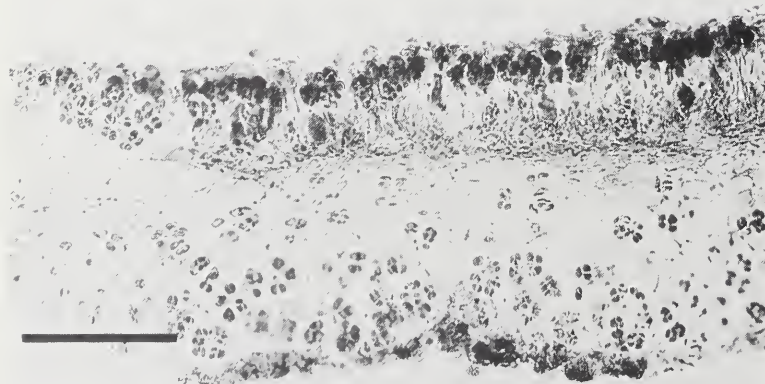


FIGURE 8.—*Gonohymenia etoshica* Brusse, part of an immersed apothecium in section in lactophenol cotton-blue. *Brusse 4155*, holotype. Bar = 100 μ m.

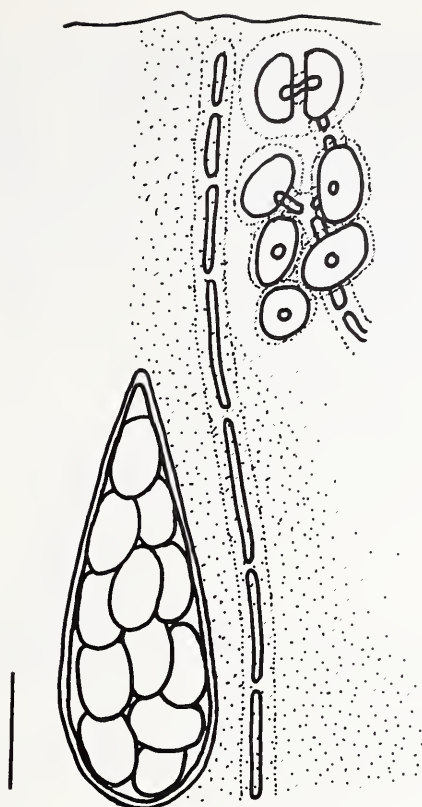


FIGURE 9.—*Gonohymenia etoshica* Brusse, ascus and paraphyses. Brusse 4155, holotype. Bar = 10 μ m.

interesting that the exciple terminates before reaching the flanks of the hymenium (Figure 8), and probably allows for intrusion of alga-bearing thalline tissue into the hymenium, during development.

Several new combinations in this genus were made by Henssen (1980), where good photographs of some species are given. Poelt (1969) treated the European species, some under *Thyrea*, in key form.

At present this species is known from two localities on the edge of Etosha Pan, on limestone.

SWA/NAMIBIA.—1816 (Namutoni): Etosha Pan, 8 km N of Namutoni, on Pan's Edge road, on limestone on W rise (–DD), F. Brusse 4177, 1984.03.20 (PRE, LD).

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F. BRUSSE

A NEW SPECIES OF *THYREA* FROM OTAVI DOLOMITE (DAMARA SYSTEM)

Thyrea otaviana Brusse, sp. nov.

Thallus subfruticulosus, e haptero radiatim lobatus, in sicco usque ad 18 mm diametro, dolomiticola. *Lobi* subascendentes, lineares, simplices vel ramosi, usque ad 10 mm longi et 0,4–1,5 (–2,5) mm lati, madefacti

400–600 μ m crassi. *Pagina superior* carbo-atra, hebetata vel granulate-isidiosa, laevis. *Cortex* 5–15 μ m crassus, paraplectenchymatus, cellulis 3,5–4,5 μ m diametro. *Stratum gonidiale* 20–50 μ m crassum; algae cyanescentes (Chroococcales aut Pleurocapsales).



FIGURE 10.—*Thyrea otaviana* Brusse, habit. Brusse 4163, holotype. Scale in mm.

Medulla hyalina, 390–560 μm crassa; hyphae in reticulum regulare dispositae, 1,4–2,5 μm crassae. *Pagina inferior* carbo-atra, hebetata, laevis, in sicco canaliculata. *Apothecia* laminaria, sessilia, lecanorina, in sicco usque ad 0,5 mm diametro. *Pagina hymeniorum* badia, nitida. *Excipulum thallinum* in lateribus 80–150 μm crassum. *Excipulum* hyalinum, pericliniate prosoplectenchymatum, 15–20 μm crassum, J–. *Hypothecium* hyalinum, 40–50 μm crassum, J+ caeruleum, paraplectenchymatum, cellulis 2,5–4,0 μm diametro. *Hymenium* hyalinum, 70–100 μm altum, J+ caeruleum. *Paraphyses* ramosae et anastomosae, septatae, luminibus 1,5–1,7 μm crassis, gelatinosae, gelatina J+ caerulea. *Asci* clavati, cum parietibus tenuibus, J–. *Ascospores* hyalinae, simplices, ovales, octonae, 11–17 $\times$ 8,0–9,5 μm . *Pycnidia* non visa.

TYPE.—1916 (Gobaub): Etosha Pan, Halali Hill, on S faces of dolomite outcrops on a SE slope (–AB), *Brusse 4163*, 1984.03.19 (PRE, holo.; BM, COLO, LD, MB, iso.). Figure 10.

Thallus subfruticose, radiately lobate from a central holdfast, up to 18 mm across when dry, on dolomite. *Lobes* subascending, linear, simple to branched, up to 10 mm long and 0,4–1,5 (–2,5) mm wide when dry, 400–600 μm thick when wet. *Upper surface* charcoal, matt to granular-isidiate, smooth. *Cortex* 5–15 μm thick, small-celled paraplectenchymatous, cells 3,5–4,5 μm diam. (Figure 11). *Algal layer* 20–50 μm thick; algae blue-green (Chroococcales or Pleurocapsales). *Medulla*



FIGURE 11.—*Thyrea otaviana* Brusse, thin section of cortex in lactophenol cotton-blue. *Brusse 4163*, holotype. Bar = 100 μm .

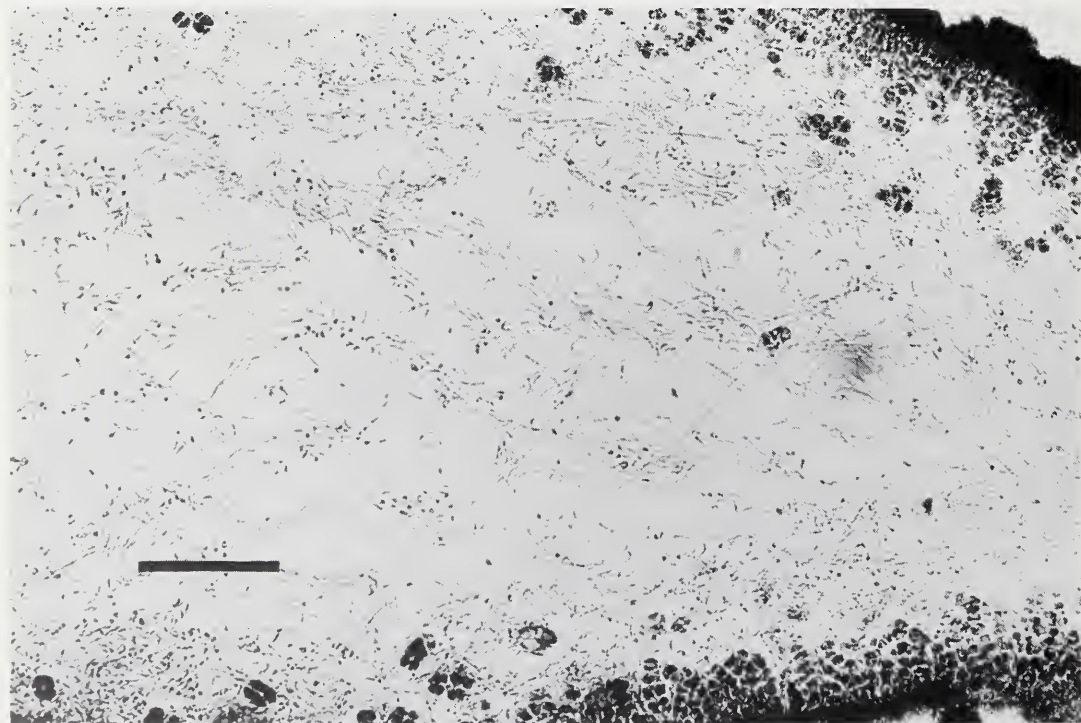


FIGURE 12.—*Thyrea otaviana* Brusse, thickish section in lactophenol cotton-blue showing reticulated medulla. *Brusse 4163*, holotype. Bar = 100 μm .

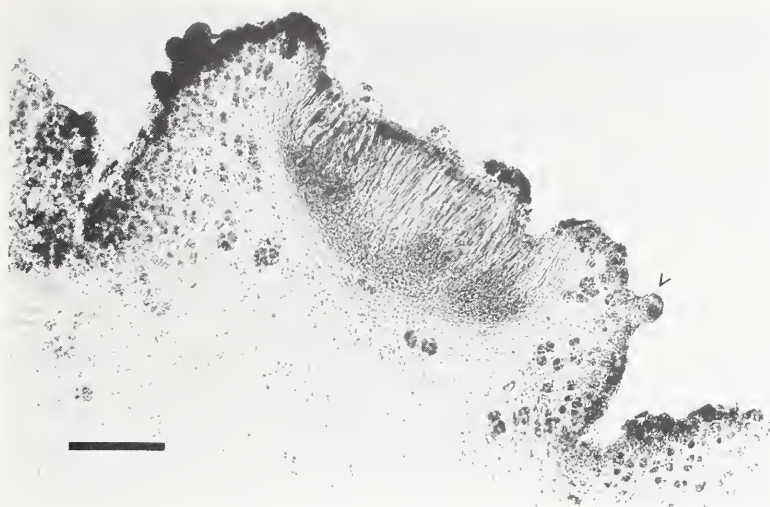


FIGURE 13.—*Thyrea otaviana* Brusse, section of apothecium in lactophenol cotton-blue. Arrow indicates a sectioned isidium. Brusse 4163, holotype. Bar = 100 μ m.

hyaline, 390–560 μ m thick; hyphae reticulately arranged (Figure 12), 1,4–2,5 μ m thick. *Lower surface* charcoal, matt, smooth, canaliculate when dry. *Apothecia* (Figure 13) laminal, sessile, lecanorine, up to 0,5 mm (dry). *Hymenial surface* brown, nitid. *Thalline exciple* 80–150 μ m thick on sides. *Exciple* hyaline, periclinial prosoplectenchyma, 15–20 μ m thick, J–. *Hypothecium* hyaline, 40–50 μ m thick, J+ blue, small-celled paraplectenchyma, cells 2,5–4,0 μ m diam. *Hymenium* hyaline, 70–100 μ m high, J+ blue. *Paraphyses* branched and anastomosed, septate, lumens 1,5–1,7 μ m thick, gelatinized, gel J+ blue. *Asci* 8-spored, clavate, walls thin, J– (Figure 14). *Ascospores* hyaline, monolocular, oval, 11–17 $\times$ 8,0–9,5 μ m. *Pycnidia* not seen.

Two new species of this genus have recently been described from Africa (Henssen 1986; Henssen, Büdel & Wessels 1985), but these, like the other species of *Thyrea* (Henssen 1980; Poelt 1969; Zahlbruckner 1926), lack a cortex, the outer surface terminating in relatively undifferentiated hyphae. *Thyrea otaviana* displays a weakly developed cortex with the hyphae becoming swollen and conglutinate near the surface, so that it is anticlinally paraplectenchymatous (Figure 11). The new species is therefore the most highly evolved species of this genus known to date (at least as far as thalline morphology is concerned). The medullary hyphae are fascicled or drawn together at regular intervals to give a reticulate pattern (Figure 12) as in *T. rotundata* Büdel *et al.* (Henssen, Büdel & Wessels 1985).

The ascospores of this new species are also larger than any known lobate (as opposed to peltate) *Thyrea*, reaching 17 μ m long in a small sample of eight ascospores measured.

The new species is presently known only from the type locality, Halali Hill, Etosha Pan on dolomite on a south-east facing slope, in the partial shade of *Moringa ovalifolia* trees. Halali hill is composed of dolomite of the Otavi group of the Damara geological sequence, and the specific name alludes to this fact. The lichen is probably more widespread on dolomite in the northern part of South West Africa/Namibia.

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The author is grateful to game rangers Karen and Trevor Nott for company during a visit to Etosha Pan and to game ranger/tracker Otavi Tsumeb for armed protection against large carnivorous and other dangerous animals.

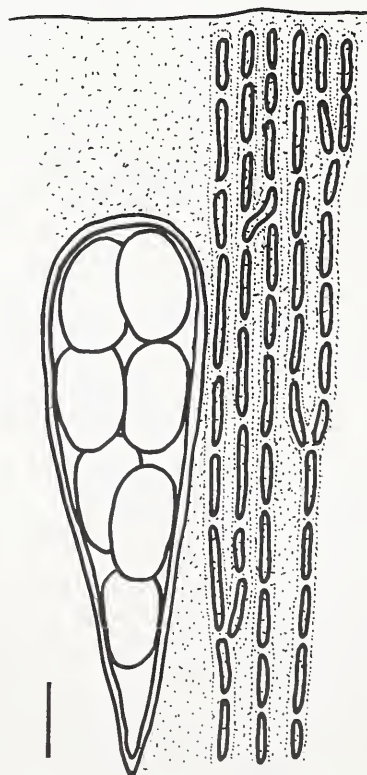


FIGURE 14.—*Thyrea otaviana* Brusse, ascus and paraphyses. Brusse 4163, holotype. Bar = 10 μ m.

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F. BRUSSE

POLYGONACEAE

A NEW SPECIES OF *OXYGONUM* FROM NATAL

Oxygonum robustum Germishuizen, sp. nov., *O. dregeano* Meisn. affinis, sed ocrea setis longis rigidis, habitu robusto decumbenti, foliisque nunquam pinnatisectis differt.

TYPE.—Natal, 2732 (Ubombo): east of Vazi Swamp, Manzengwenya (–BB), Moll 4722 (PRE, holo.; NH, iso.). Figure 15.

Robust, spreading, decumbent herb much branched

from the base; arising from a long thick vertical woody rootstock. Old stems reddish brown, sparsely pilose; young stems glabrous, longitudinally ridged, brown-punctate. *Ocrea* membranous, reddish brown, 8–10 mm long, fringed with rigid bristles 8–10 mm long, pilose, brown-punctate, adnate to the base of the leaves. *Leaves* simple, sessile, alternately arranged, glabrous, brown-punctate, lamina obovate to elliptic to spatulate, (37–) 45–75 (–94) × (8–) 10–21 (–23) mm, acuminate, mar-

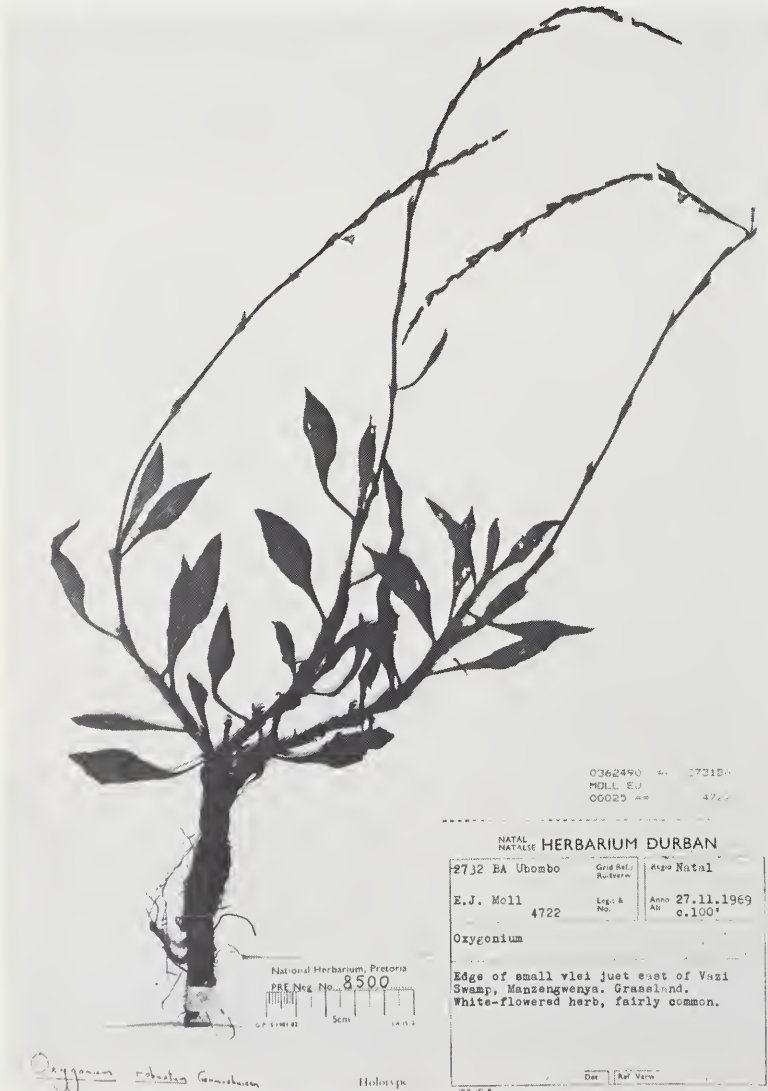


FIGURE 15.—Holotype of *Oxygonum robustum* Germishuizen.

gins entire or occasionally sharply toothed. *Inflorescence* a long lax thyrse with fascicles of up to 4 flowers in the axils of the bracts. *Flowers* bisexual. *Perianth* 5-lobed, up to 7 mm long, glabrous, white. *Stamens* 8, inserted on the inner perianth; anthers reddish brown, 1 mm long; filaments 4 mm long. *Styles* 3, connate at the base; stigmas capitate. *Fruit* a 3-angled nut.

NATAL.—2632 (Bella Vista): Maputa to Kosi Nature Reserve (–DD), Edwards 2586. 2732 (Ubombo): 16 km north of Lake Sibayi (–BA), Vahrmeyer & Toelken 259; Muzi Swamp $\pm$ 2 km from Phelandaba turnoff on road to Mbazwana (–BA), Germishuizen 3546; Vazi Swamp (–BB), Stephen, Van Graan & Schwabe 1177; east of Vazi Swamp, Manzengwenya (–BB), Moll 4722; Mbazwana (–BC), Gerstner 704; Manzengwenya Forest Station (–BD), Vorster 2586; Bangazi Lake (–DA), Strey 4991. 2832 (Mtubatuba): 25 km north of Mtubatuba (–AB), Codd 2022; near Fannies Island Camp (–AB), Ward 1493; Dukuduku U176 (–AC), Strey 5522; St Lucia, Eastern Shore State Forest (–AB), Nicholas 1624; Nseleni Nature Reserve (–CA), Bourquin & Ndlovu 17; 80 km from Arboretum turnoff, on old main road to Empangeni (–CC) Ngwenya 240; Richards Bay (–CC), Lawn 1725 & 1726; Rump s.n. (NH 20120).

O. robustum is endemic to Natal, occurring in a restricted area (Figure 16) of coastal grassland and coastal dune forest. The first record of the species in the Natal Herbarium was collected by W. G. Rump s.n. (NH 20120) during July 1929 at Richards Bay. All the material cited above was incorrectly identified as *O. dregeanum*. Although these two taxa are sympatric, *O. robustum* can be distinguished from *O. dregeanum* by its robust and decumbent habit, by the ocrea fringe having

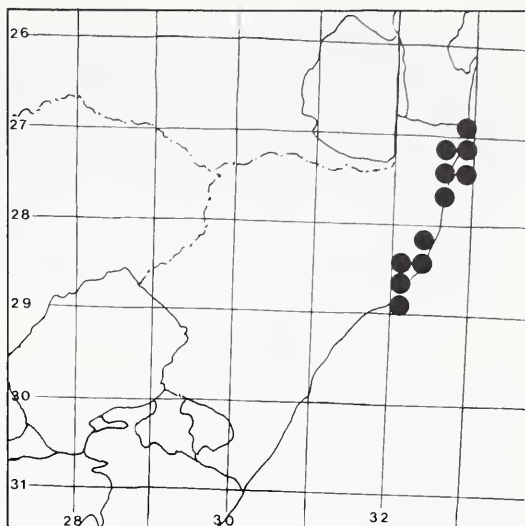


FIGURE 16.—Distribution of *Oxygenum robustum* Germishuizen.

long rigid bristles and by the leaves never being pinnatisect.

The specific epithet *robustum* refers to the robust habit of this species.

G. GERMISHUIZEN

TELOSCHISTACEAE

A NEW SPECIES OF *CALOPLACA* FROM SOUTHERN AFRICA

INTRODUCTION

The genus *Caloplaca* Th. Fr. is one of the largest lichen genera known. The total number of species has been estimated at almost 500 (Santesson 1970). Although many of the published species names will be reduced to synonyms in future revisions, there are still unknown species to be discovered in this fascinating genus. The genus is also extremely variable and incorporates many different structural forms, which, if measured by today's taxonomic concepts in, for example, the Lecideaceae or Parmeliaceae, would have been recognized at generic level. However, too many intermediate forms are present to justify a more diversified generic taxonomy in the Teloschistaceae (see Hafellner & Poelt 1979; Poelt & Hafellner 1980; Poelt & Pelleret 1984; Wunder 1974).

In addition many species show extremely broad morphological variations, which normally also correlate with rather extensive geographical ranges. In taxonomic terms this variation is usually extremely hard to define. Yet, many characteristic species with geographically limited distributions are also present in the genus. The new species described here belongs to this latter category. I recognized the unique characteristics of the species for the first time in undetermined material from Lesotho. On a field trip in southern Africa with Mr Frank Brusse at the beginning of 1986, we collected the new

species in several different localities along the Drakensberg escarpment. The species is named in honour of my older colleague Dr Ove Almborn, who collected it as far back as 1953.

Caloplaca almbornii Kärnefelt, sp. nov.

Thallus areolis dispersis sanguineis 0,2–3,0 mm diametro compositus. *Apothecia* immersa, postea parum prominentia, lecideina; discus aurantiacus. *Ascosporae* polaribiloculares, 9,5–13,5 $\times$ 3,8–4,7 μ m, septum $\pm$ 2 μ m crassum. *Thallus* K+ purpureus, parietinum adest.

TYPE.—Lesotho, 2929 (Underberg): Mokhotlong, mountain behind Pack Horse Inn (–AC), 1963, Kofler (LD, holo.).

Thallus composed of scattered, more or less circular, usually convex areoles, 0,2–1,0 mm across, or when flatter up to 3,0 mm across, then secondarily cracked into several small areoles; usually bright reddish or occasionally more orange pigmented. *Cortical layer* $\pm$ 40–70 μ m thick, covered by a $\pm$ 10 μ m thick pigmented layer, paraplectenchymatous, composed of anticlinal cells, occasionally penetrating the clustered algae in up to 150 μ m deep strands. *Photobiont* clustered, occasionally nearing the surface, single cells green and spherical, $\pm$ 10 μ m in diameter. *Medullary layer* rather dense, 130–350 μ m deep (Figure 17F). *Apothecia* often present, immersed, becoming slightly raised with maturity,

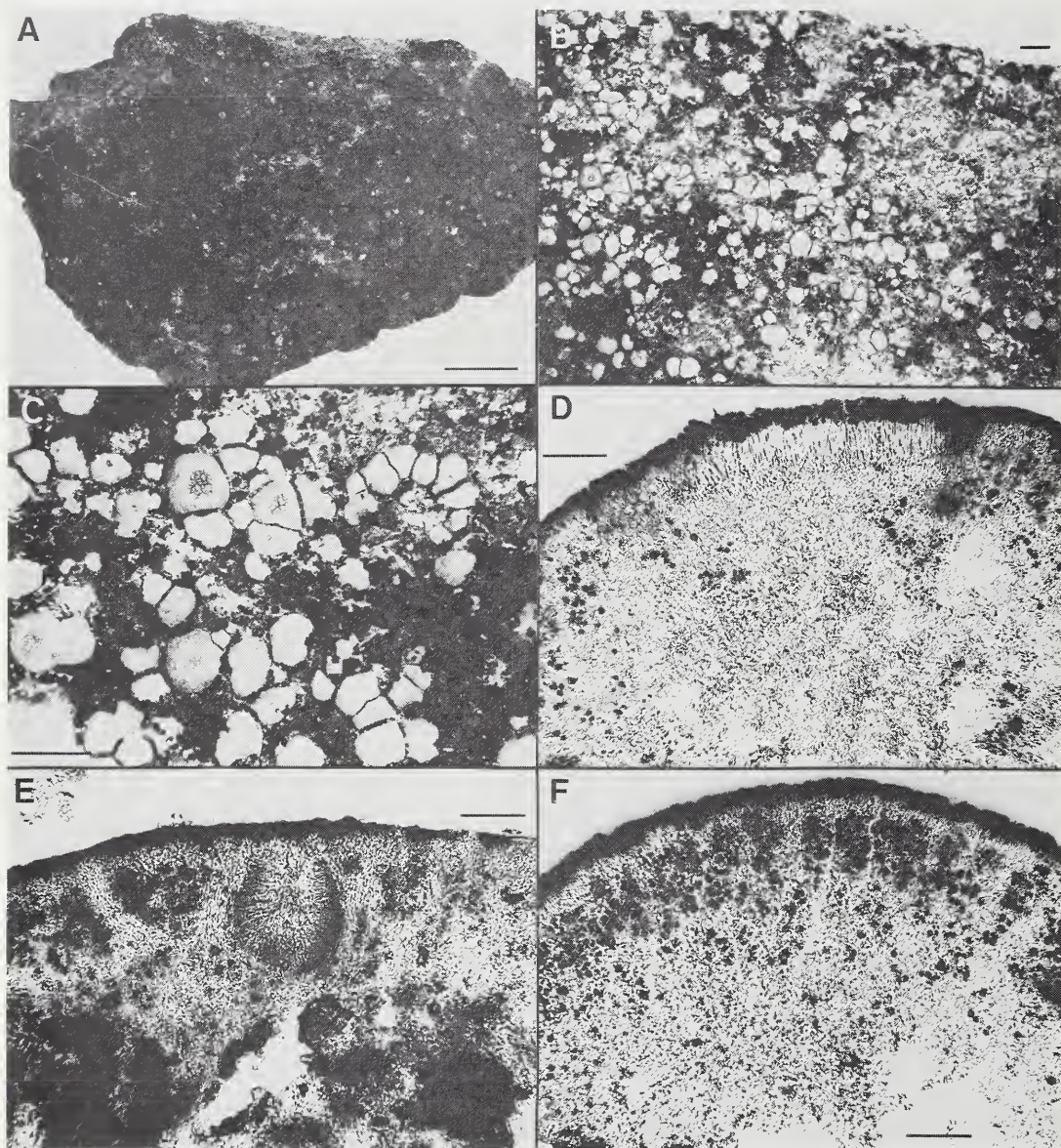


FIGURE 17.—*Caloplaca almbornii*. A, specimen with very scattered areoles, Kärnefelt 8626-7, bar = 10 mm; B & C, close up of thallus, Kofler s.n., bar = 1 mm; D, cross section of areole showing immersed apothecium, Kärnefelt 8625-20, bar = 100 μ m.; E, cross section of areole with conidiomata, Kärnefelt 8626-8, bar = 100 μ m.; F, cross section of areole, Kärnefelt 8625-20, bar = 100 μ m.

often one per areole (Figure 17C & D), to several together on the broader cracked areoles; disc very small, 0,1–0,7 mm across, covered by an orange pigment. *Excipulum* occasionally seen as a thin pale orange ring around the disc, 10–20 μ m thick. *Hymenium* $\pm$ 65–95 μ m thick, covered by a pigmented, granular, epihymenial layer up to 35 μ m thick. *Asci* 45–55 $\times$ 8–10 μ m. *Ascospores* ellipsoidal, polaribilocular, 9,5–13,5 $\times$ 3,8–5,7 μ m; septum $\pm$ 2 μ m thick. *Hypothecium* forming a relatively flat dome below the excipulum, 35–55 (–150) μ m deep, hyaline. *Conidiomata* scattered, 110–170 μ m large, pyriform (Figure 17E); conidia very small, slightly bifusiform, $\pm$ 3,5 $\times$ 0,5 μ m. *Reactions* K+ blood red, C–, KC– and P–. *Caloplaca almbornii* contains parietin only (TLC).

Caloplaca almbornii is characterized particularly by the remarkable structure of the thallus composed of scattered convex areoles, forming small red-spotted patches (Figure 17A, B & C). Apart from thallus colour and structure of the ascomata, *C. almbornii* is reminiscent of *Aspicilia contorta* (Hoffm.) Krempelh. which occurs on various calcareous rocks in Europe. The areoles are often embedded in other blackish, crustose, sterile lichens. It is therefore not possible to demonstrate whether the areoles are connected by anastomosing hyphae, or by a thin hypothallus. Flatter and up to 3 mm broad areoles can occasionally be found. The colour of the areoles is sometimes more orange than bright reddish.

Caloplaca almbornii appears to be isolated in the genus and is not clearly related to any other species. It

shows some affinities with the *C. cinnabarina* group, which is a very variable species complex occurring mainly at lower altitudes in southern Africa. *C. almbornii* and the *C. cinnabarina* group have similar anatomical characters but differ considerably in the structure of the thallus. The bright reddish colour is most reminiscent of the colour of *C. haematodes* (Massal.) Zahlbr. *C. almbornii* also differs chemically by containing only parietin, whereas most other species examined contain more than one anthraquinone.

Caloplaca almbornii is endemic to southern Africa and is known only from mountainous regions, mainly at rather high altitudes. It has been found locally abundant at 2 000–3 000 m in the Drakensberg in Lesotho, the Transkei and Natal. Furthermore, it has been found in the Orange Free State close to the Lesotho border, in the easternmost part of the Cape Province and in the Matopo Hills in SW Zimbabwe (Figure 18). The species could probably occur in the eastern mountainous region of the Transvaal, located between the northernmost outpost in Zimbabwe and the Drakensberg centre in the south. I have, however, not been able to find it during several excursions, specially undertaken to this otherwise lichenologically very rich eastern extension of the Drakensberg. The eastern Transvaal mountains are presumably too low in altitude.

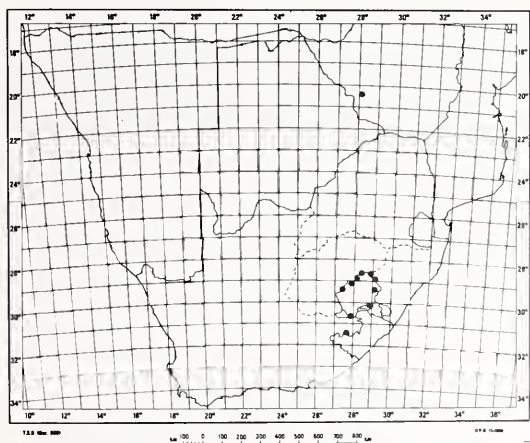


FIGURE 18.—Distribution of *Caloplaca almbornii*.

In the Mont-aux-Sources region in the northern part of the Drakensberg, I found *C. almbornii* locally abundant on sloping dark basaltic rocks with dripping water. In the southern part of the Drakensberg the species was also found locally in the cave sandstone belt, growing on flat surfaces with stagnant water, or on sloping surfaces with dripping water. Most of these habitats are easily recognized by the blackish colour caused by a variety of crustose lichens and possibly also by Cyanobacteria. *C. almbornii* is easily discovered here, where it contrasts as patches of bright red spots against the dark rock surface.

ZIMBABWE.—2028 (Bulawayo): Matopo Hills, Pomowe (–AC), 1963, *Kofler* (LD).

O.F.S.—2828 (Bethlehem): Clarens (–CB), 1943, *Plank 1880* (PRE).

NATAL.—2828 (Bethlehem): Royal Natal National Park, mountain path to Mont-aux-Sources from entrance gate at the end of mountain road from Phuthaditjhaba (–DB), 1986, *Kärnefelt 8626-8, 8626-10, 8626-20, 8626-22, 8626-46* (LD); Little Tugela area (–DB), 1943, *Esterhuysen 8875* (BOL). 2829 (Harrismith): Cathedral Peak area, Organ Pipes (–CC), 1953, *Almborn 9037, 9058* (LD).

QWA-QWA.—2828 (Bethlehem): Mont-aux-Sources area, mountain path from entrance gate to Royal Natal National Park at the end of mountain road from Phuthaditjhaba (–DB), 1986, *Kärnefelt 8625-8, 8625-12, 8625-14, 8625-15, 8625-20–8625-23* (LD).

LESOTHO.—2927 (Maseru): Machache Mtn (–AD), 1929–1930, *Hewitt* (TRH, 4 collections); Popanyane (–BB), 1963, *Kofler 3523* (LD). 2828 (Bethlehem): Leribe, Oxbow (–CC), 1953, *Kofler* (LD, 2 collections); Mapoteng, 30 miles E of Leribe (–CC), 1963, *Kofler 310195* (LD, 2 collections). 2929 (Underberg): Mokhotlong, behind Pack Horse Inn (–AC), *Kofler* (LD, 2 collections).

TRANSKEI.—3029 (Matatiele): Qachas Nek, close to the Lesotho border, cave sandstone formations (–BB), 1986, *Kärnefelt 8630-44–8630-51* (LD).

CAPE.—3027 (Lady Grey): Naude's Nek, on R396 to Rhodes from Elands Height (–DB), 1986, *Kärnefelt 8632-3–8632-6* (LD); mountain 6 miles from Naude's Nek, on the way to Ben McDhuy (–DB), 1963, *Kofler 311166*. 3127 (Lady Frere): Barkly Pass on R58 between Barkly Pass and Elliot (–BB), 1986, *Kärnefelt 8633-1–8633-3* (LD).

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Cetraria (Parmeliaceae) and some related genera on the African continent

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Keywords: *Bryoria*, *Cetraria*, new records, Parmeliaceae, *Platismatia*, southern Africa, taxonomy

ABSTRACT

Four species are reported new for the lichen flora of southern Africa: *Bryoria fuscescens* (Gyeln.) Brodo & D. Hawksw., *B. motycae* (D. Hawksw.) Brodo & D. Hawksw., *Cetraria chlorophylla* (Humb.) Vain. and *Platismatia glauca* (L.) Culb. & Culb. (Parmeliaceae), found at high elevations in Natal and south-west Cape. *B. fuscescens*, *B. motycae* and *P. glauca* were previously known from a few localities, also at high elevations, in east Africa. The genus *Cetraria* s. str. was previously unknown on the African continent.

UITTREKSEL

Vier spesies word nuut aangeteken vir die ligen-flora van suidelike Afrika: *Bryoria fuscescens* (Gyeln.) Brodo & D. Hawksw., *B. motycae* (D. Hawksw.) Brodo & D. Hawksw., *Cetraria chlorophylla* (Humb.) Vain. en *Platismatia glauca* (L.) Culb. & Culb. (Parmeliaceae), wat hoog bo seespieël in Natal en suidwes-Kaap aangetref word. *B. fuscescens*, *B. motycae* en *P. glauca* was voorheen bekend vanaf 'n paar plekke, ook hoog bo seespieël, in oos-Afrika. Die genus *Cetraria* s. str. was voorheen onbekend op die vasteland van Afrika.

INTRODUCTION

During my work on the genera *Coelocaulon* and *Cornicularia* (Kärnefelt 1986), I came across a few noteworthy specimens in the Bolus Herbarium, University of Cape Town, collected by Ms Elsie Esterhuysen. Apart from the material of *Coelocaulon epiphorellum*, which was then new to Africa, Ms Esterhuysen's collections also included four other species new to southern Africa: *Bryoria fuscescens* (Gyeln.) Brodo & D. Hawksw., *B. motycae* (D. Hawksw.) Brodo & D. Hawksw., *Cetraria chlorophylla* (Humb.) Vain. and *Platismatia glauca* (L.) Culb. & Culb. (Parmeliaceae). With the discovery of *Cetraria chlorophylla* in southern Africa the genus *Cetraria* s. str. is also reported as being new to the African continent.

MATERIAL AND METHODS

The material from southern Africa was investigated chemically for secondary compounds and was compared anatomically with material from the northern hemisphere in LD, and with material from the east African mountains in UPS.

Cetraria chlorophylla (Humb.) Vain. in Acta Societatis pro Fauna et Flora Fennica 13: 7 (1896).

Lichen chlorophyllus Humb.: 20 (1793). Type: In cortice Pyni sylvestris beym Vorwerk Hals copiose (B. Willdenow).

Thallus subfruticose or foliose, ± 10 – 20 mm across; lobes irregularly branched, ± 0.5 mm broad at tips, ± 2 – 3 mm at base, weakly channelled to flat, with scattered marginal soralia especially towards the lobe tips, and scattered marginal cilia; upper surface brown to pale brown, glossy, rather smooth; lower surface paler brown to whitish, wrinkled or sulcate, with rather frequent pale

rhizinae; ascomata and conidiomata not observed. Cortex paraplectenchymatous, ± 25 – 30 μ m thick, covered by a thin ± 5 μ m thick pigmented epicortical layer, composed of 1–2 layers of densely packed isodiametric cells with rather distinctive lumina; photobiont green and spherical forming a more or less continuous layer; medulla composed of loose hyphae; lower cortical layer similar to the upper layer (Figure 1C). Reactions K–, C–, KC– and P–. *Cetraria chlorophylla* contains protolichesterinic acid.

Cetraria chlorophylla is characterized by the rather small, subfruticose to foliose thallus, brown to usually more greenish brown in the northern hemisphere, and glossy lobes with scattered marginal soralia and cilia (Figure 1A). It is a locally common species both on conifers and on deciduous trees in north-western and central Europe (see Wirth 1980). In western North America it is also one of the most common foliose species (Hale 1979; Thomson 1984). In continental parts of Eurasia and North America, however, *C. chlorophylla* is very rare or lacking, and relatively mild and oceanic climatic regions provide conditions favourable for the growth of this species. *C. chlorophylla* has also been reported from Japan (Sato 1965) and from Tierra del Fuego (Räsänen 1932) and Australia (Filson 1983) in the southern hemisphere. The species was, however, not treated by Galloway (1985) in the new lichen flora of New Zealand.

The material from southern Africa was collected at 750–900 m alt. on shelves on the NE side of Table Mountain in the SW Cape (Figures 2 & 3). This is not surprising, as Table Mountain, with its mild and humid winters and relatively high rainfall, offers favourable conditions for a diversified lichen vegetation. It is one of the richest lichen localities in southern Africa and is the type locality of numerous lichen species.

It is premature to speculate on the origin and dispersal of *C. chlorophylla* in the southern hemisphere and on the

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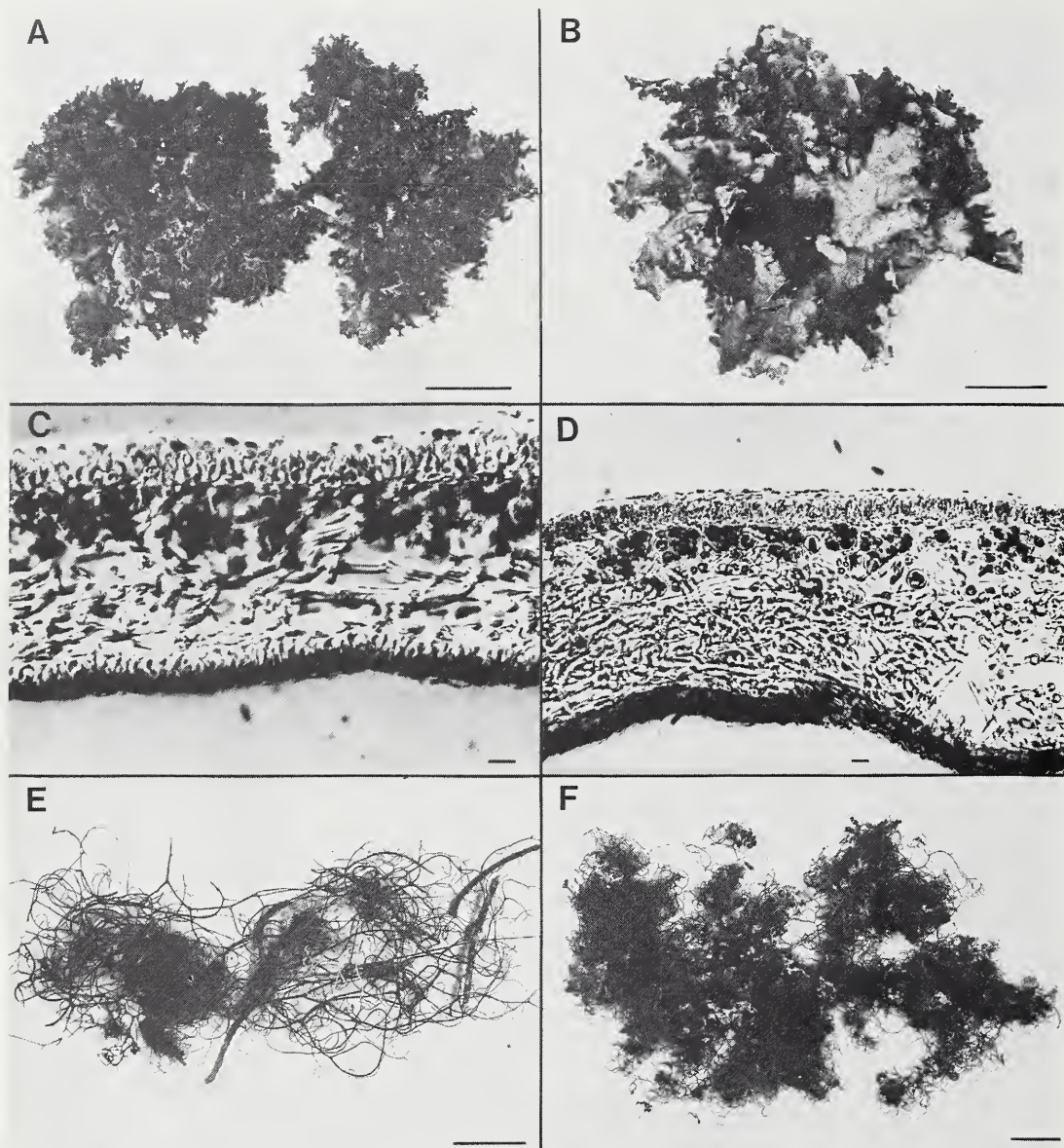


FIGURE 1.— A, *Cetraria chlorophylla*, Esterhuysen 22911, bar = 10 mm; B, *Platismatia glauca*, Esterhuysen 10261, bar = 10 mm; C, *C. chlorophylla*, cross section of thallus, interference contrast micrograph, Esterhuysen 10261, bar 10 μ m; D, *P. glauca*, cross section of thallus, light micrograph, Esterhuysen 10261, bar = 10 μ m; E, *Bryoria fuscescens*, Esterhuysen 10261, bar = 10 mm; F, *B. motykae*, Esterhuysen 21356, bar = 10 mm.

only record yet known from southern Africa. I am not inclined to believe, however, that the species has been introduced in modern times, as it occurs at relatively high elevations in a natural habitat (see Kärnefelt 1986). Presumably the species could occur in similar regions in southern Africa with favourable climatic conditions, such as the Drakensberg escarpment as well as at high altitudes in the east African mountains.

CAPE.—3318 (Cape Town): Table Mountain, cliffs, NE side, on shelves, 2500–3000 ft [750–900 m] (–CD), 1954, Esterhuysen 22911 (BOL).

***Platismatia glauca* (L.) Culb. & Culb.** in Contributions from the United States National Herbarium 34: 530 (1968).

Lichen glaucus L.: 1148 (1753). Type: Europe, Linnean Herbarium Sheet 1273–139 (LINN, lecto.).

Thallus foliose, loosely attached, 20–50 mm across; lobes 5–10 mm broad; upper surface yellowish, with dark brownish areas, reticulately wrinkled, with scattered marginal soralia; lower surface dark brown, reticulately wrinkled to pitted (Figure 1B); *ascomata* and *coni-*

diomata not observed. *Upper cortex* prosoplectenchymatous, 20–30 μm thick, composed of strongly pachydermatous cells with indistinct cell lumina; *photobiont* green, spherical, concentrated near the upper cortex; *medulla* loose, 50–100 μm thick; lower cortex similar to the upper cortex, heavily pigmented (Figure 1D). Reactions K–, C–, KC– and P–. *Platismatia glauca* contains caperatic acid and atranorin.

This well known species from the northern hemisphere has been described in detail by Culberson & Culberson (1968). *Platismatia glauca* is locally common on conifers and deciduous trees and occasionally also on rocks in western Europe and North America. It is extremely common especially in the western American states, but is found more rarely in the eastern provinces (Hale 1979; Thomson 1984). Like *C. chlorophylla*, *P. glauca* is apparently also favoured by a rather mild oceanic climate.

In the southern hemisphere *P. glauca* is also known from the south-westernmost part of South America (Culberson & Culberson 1968) and from Australia (Filson 1983), but it is so far unknown from New Zealand (Galloway 1985).

On the African continent *P. glauca* was previously known from Kenya, Tanzania and Uganda (Figure 3), where it occurs at rather high altitudes from 3 200–3 500 m (Krog & Swinscow 1975). The two new records from southern Africa were found at $\pm 2\,400$ m in the Cathedral Peak area in the Natal Drakensberg and at $\pm 1\,800$ m in the Sneeuberg in the Sederberg Mountains in the western Cape (Figure 2). The scattered montane African records may indicate that the localities represent the remnants of a much wider pre-Pleistocene distribution.

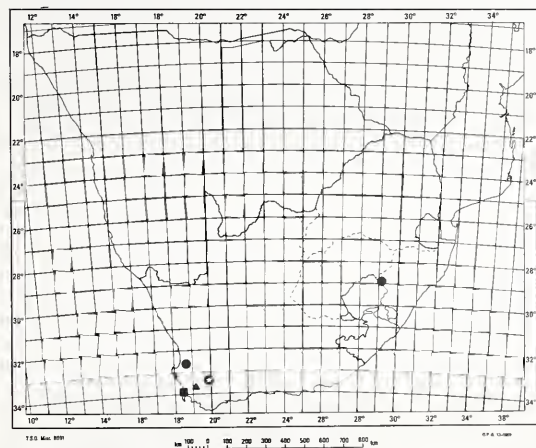


FIGURE 2.—Distribution in southern Africa of: *Cetraria chlorophylla*, ■; *Platismatia glauca*, ●; *Bryoria fuscescens*, ◐; *B. morykae*, ▲.

NATAL.—2829 (Harrismith): Cathedral Peak area, tree trunk, 8000 ft [2 500 m], (–CC), 1944, Esterhuysen 10261 (BOL).

CAPE.—3218 (Clanwilliam): Sederberg, Sneeuberg, shaded ledge on cliffs, south side, 6000 ft [1 800 m] (–DA), 1952, Esterhuysen 20044 (BOL).

***Bryoria fuscescens* (Gyeln.) Brodo & D. Hawksw.** in Opera Botanica 42: 83 (1977).

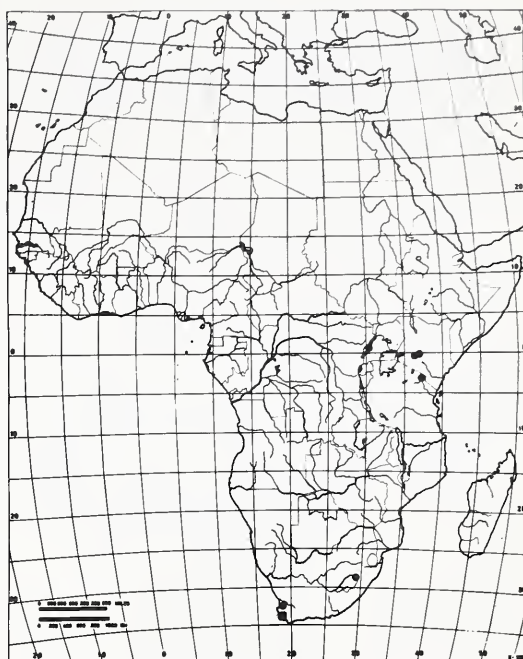


FIGURE 3.—Distribution in Africa of: *Cetraria chlorophylla*, ■; *Platismatia glauca*, ●.

Alectoria fuscescens Gyeln.: 55 (1932). Type: Finland, Tavastia austr., Hollola, ad truncos Pini locis apricioribus in silva, J. P. Norrlin, 1882, Nyl. & Norrl., Lich. Fenn. Exs. no. 466 (BP, 33.947, lecto.).

Thallus subpendent, 30–60 mm across; *main lobes* with rather abundant short lateral branches, up to 0.3 mm wide, pale brown to blackish; with abundant fissural soralia, from rather small up to 0.5 mm wide; scattered small fissural pseudocyphellae present; *ascomata* and *conidiomata* not observed (Figure 1E). Anatomical characters similar to most other species of *Bryoria*, the cortical layer composed of periclinial hyphae. *Reactions* of medulla and particularly the soralia, K–, C–, KC– and P+. *B. fuscescens* contains fumarprotocetraric acid, clearly indicated by TLC of the examined material.

Within the genus *Bryoria*, *B. fuscescens* is one of the most difficult species to circumscribe. It is widely distributed within the boreal zone in the northern hemisphere, where it also occurs in many different habitats, frequently on trees, but also on the ground and on rocks. The known morphological and chemical variation is fairly wide and may be partly the result of different responses to the local diversified habitat selection pressures (see Brodo & Hawksworth 1977; Bystrek 1963; Hawksworth 1972; Hawksworth 1973).

The material from southern Africa was collected at $\pm 1\,680$ m altitude on twigs at Horseshoe Peak, in the Hex River Mountains in the western Cape (Figure 2). This is the first known record of a member of the genus *Bryoria* in southern Africa. The earlier records published by Doidge (1950) as *Alectoria chalybeiformis* f. *terrestris* and *A. jubata* have been re-examined and are apparently filamentous Cyanobacteria.

Apart from southern Africa, *B. fuscescens* is also known from several localities in the ericaceous zone and

in the alpine zone from 3 200 to 4 900 m altitude, in Ethiopia, Kenya, Tanzania and Uganda (Krog & Swinscow 1975). Figure 4.

CAPE.—(3319 Worcester): Hex River Mountains, Horseshoe Peak, on ledges on south side, on twigs, 5500 ft [1 680 m] (–DD), 1953, *Esterhuysen 22189* (BOL).

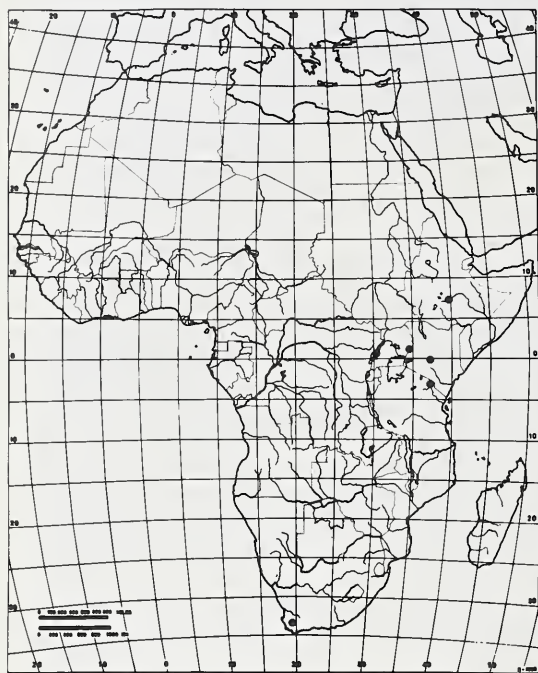


FIGURE 4.—Distribution in Africa of *Bryoria fuscescens*.

***Bryoria motykae* (D. Hawksw.) Brodo & D. Hawksw.** in *Opera Botanica* 42: 155 (1977).

Alectoria motykae D. Hawksw. 124: 124 (1971). Type: Kenya, Mt Kenya, Teleki Valley, alpine regions, on vertical surfaces of boulders in the upper parts of the valley, alt. 4 200 m, 1948, *Hedberg 1720b* (UPS, holo.).

Thallus prostrate, 10–30 mm long; *main lobes* with arcuately curved lateral branches, dark brown or partly blackish, up to 0.2 mm wide, with scattered fissural pseudocyphellae, up to 0.5 mm broad; *ascomata* and *conidiomata* not observed. *Anatomical characters* similar to most other species of *Bryoria*, the cortical layer composed of periclinal hyphae. *Reactions* of medulla and pseudocyphellae, K–, C–, KC– and P+. *Bryoria motykae* contains fumarprotocetraric acid according to Hawksworth (1971). However, TLC gave only weak spots in the examined material, which included the type specimen kept at UPS, and the P reaction was feint as well.

Bryoria motykae is characterized by the dark brown or partly blackish main lobes with arcuately curved lateral branches, broad fissural soralia and scattered fissural pseudocyphellae. The material from southern Africa, however, differs slightly from the type material from Mount Kenya (*Hedberg 1720b*, UPS) in the absence of soralia, but corresponds in the remaining characters with the type (Figure 1F). According to Hawksworth (1971) pseudocyphellae are lacking, contrary to my observations on re-examination of the type material. Krog &

Swinscow (1975) had apparently also observed pseudocyphellae, because they mention that the fissural soralia developed from minute pseudocyphellae.

Among the possibly related species, Hawksworth (1971) pointed out the resemblance to *B. furcellata* (Fr.) Brodo & D. Hawksw. (as *Alectoria nidulifera* Norrl. in Nyl.) in some characters. *B. furcellata* is, however, distinguished by the more spinulate lobes and the rather abundant isidiate soredia. *B. motykae* is also reminiscent of *B. simplicior* (Vain.) Brodo & D. Hawksw., in the structure of the soredia (Hawksworth 1971). *B. simplicior* is, however, a normally corticolous species, characterized by a typical caespitose habit and very distinctive soredia. In addition *B. simplicior* also lacks secondary compounds.

B. bicolor (Ehrh.) Brodo & D. Hawksw. is somewhat reminiscent of *B. motykae* in the similar fissural pseudocyphellae, but this species is distinguished by the rather short lateral spinules and differently coloured main lobes. Furthermore, Krog & Swinscow (1975) included *B. ruwenzoriensis* (D. Hawksw.) Brodo & D. Hawksw., recorded from east Africa, in *B. bicolor*.

In my opinion *B. motykae* is presumably associated with the *B. fuscescens* aggregate, which also occurs in the east African mountains. We have to await further studies on this difficult species complex before the status of *B. motykae* can be determined with certainty.

The material from southern Africa was collected at $\pm 1\ 300$ m on sandy hollowed rock surfaces on the Groot Drakenstein Mountain near Paarl in the western Cape (Figure 2).

Apart from southern Africa, *B. motykae* is also known from Mt Kenya, where it occurs at $\pm 3\ 500$ m (Figure 5). The record published by Krog & Swinscow (1975)



FIGURE 5.—Distribution in Africa of *Bryoria motykae*.

from Mt Kilimanjaro in Tanzania, proved after re-examination to belong to the *B. fuscescens* group.

CAPE.—3319 (Worcester): Groot Drakenstein Peak, amongst other lichens on sandy hollowed rock surfaces, 4500 ft [1 370m], (—CA), 1953, *Esterhuysen 21356* (BOL).

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Species groups in the genus *Ehrharta* (Poaceae) in southern Africa

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Keywords: anatomy, *Ehrharta*, morphology, Poaceae, southern Africa, taxonomy

ABSTRACT

Ehrharta Thunb. is a genus of Gondwanaland distribution with its centre of diversity in the winter rainfall Fynbos Biome of southern Africa. In recent subfamily treatments *Ehrharta* has proved difficult to place satisfactorily, and during the past five years it has been moved between Bambusoideae and Arundinoideae. However, most previous systematic studies using cryptic characters have covered only four taxa out of about 35. The present study includes all African taxa, and demarcates seven species groups on the basis of both spikelet morphology and leaf blade anatomy. Parallelism and/or convergence in vegetative macromorphology within and between the species groups is widespread, and is similar, in some cases, to adaptations found in other plant families in the Fynbos Biome. However, these macromorphological trends are not reflected in the leaf anatomy. Leaf anatomy is generally consistent with the spikelet morphology. Some anatomical differences between the species groups in *Ehrharta* appear to be as great as differences between taxa of much higher ranks elsewhere in the Poaceae. This wide range of variability may be related to an early divergence of Ehrharteae from other grasses, as suggested by the Gondwanaland distribution, and may explain the difficulty of placing this fascinating yet baffling genus in a subfamily.

UITTREKSEL

Ehrharta is 'n genus van Gondwanaland-verspreiding met sy middelpunt van verskeidenheid in die winterreënval-Fynbosbroom van suidelike Afrika. In onlangse subfamilie-behandelings is dit moeilik gevind om *Ehrharta* bevredigend te plaas, en gedurende die afgelope vyf jaar is dit oor en weer in Bambusoideae en Arundinoideae geplaas. Die meeste vorige sistematiese ondersoeke waarin verskuilde kenmerke gebruik is, het slegs vier taksons uit ongeveer 35 gedek. Die onderhawige ondersoek sluit al die Afrika-taksons in, en baken sewe spesiegroepe af op grond van die morfologie van die blompakkie en die anatomie van die blaarskyf. Parallelisme en/of konvergensie in vegetatiewe makromorfologie binne en tussen spesiegroepe is wydverspreid en is in sommige gevalle soortgelyk aan aanpassings wat by ander plantfamilies in die Fynbosbroom aangetref word. Hierdie makromorfologiese neigings word nie in die blaaranatomie weerspieël nie. Blaaranatomie is oor die algemeen in ooreenstemming met die morfologie van die blompakkie. Sommige anatomiese verskille tussen die spesiegroepe in *Ehrharta* blyk net so groot te wees soos verskille tussen taksons van 'n veel hoër rang elders in die Poaceae. Hierdie wye verskeidenheid mag verband hou met 'n vroeë divergensie van Ehrharteae vanaf ander grasse, soos aangedui deur die Gondwanaland-verspreiding, en mag 'n verklaring bied waarom hierdie bekorende maar raaiselagtige genus moeilik in 'n subfamilie geplaas kan word.

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INTRODUCTION

In the most recent treatment (Willemse 1982), the tribe Ehrharteae Nevski (1937) consists of only a single genus, *Ehrharta* Thunb. (1779) which includes the genera *Microlaena* R. Br., *Petriella* Zotov and *Tetrarhena* R. Br. Its distribution area in southern Africa, southwestern, southern and eastern Australia, Tasmania, New Zealand and Malesia falls within the cool-temperate Gondwanaland region (Figure 1). The centre of diversity for the genus is the winter rainfall Cape Floristic Region (Goldblatt 1978) or Fynbos Biome (Rutherford & Westfall 1986) of southern Africa, with about 35 taxa, the other 10 taxa being distributed unevenly elsewhere in the range of the genus. In southern Africa, *Ehrharta* can be divided into seven species groups demarcated on the basis of both spikelet morphology and leaf blade anatomy.

An understanding of the variation within *Ehrharta* in southern Africa is necessary, not only to improve the classification of the local taxa, but also to show the relationships between the bulk of the genus in southern Africa and its representatives in other Gondwanaland

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FIGURE 1.—Worldwide distribution of *Ehrharta*, showing the number of species and infraspecific taxa reported for various areas. The number of southern African species naturalized in India and Australia are indicated with an asterisk.

regions. *Ehrharta* may therefore serve as an additional plant group to indicate the floristic history of the Gondwanaland continents, and is the first representative of the Poaceae with this potential to be studied with this aim.

Additional information on *Ehrharta* is required because its position within the Poaceae is not yet settled. Since the time of Bentham & Hooker (1883), the group has been shuffled between the Phalarideae and the Oryzae of the Pooideae (Festucoideae), the Ehrharteae and Arundineae of the Arundinoideae, the Ehrharteae of the Oryzoideae, and the Ehrharteae and the Oryzaneae of the Bambusoideae. Modern studies based on cryptic characters such as leaf anatomy, chromosomes and embryo types have enabled most grass tribes to be clearly placed in one of about five subfamilies, but there is still no general agreement regarding the affinities of the Ehrharteae. Prat (1960) and Clifford & Watson (1977) place the tribe in an unclassified residue that does not fit neatly into any of the modern subfamilial concepts of the Poaceae. Most recently, Ehrharteae has been removed from the Arundinoideae (Renvoize 1981) to the Bambusoideae (Renvoize 1985; Watson *et al.* 1985).

The instability of the higher classification of the Ehrharteae may be partly a result of the high degree of variation in its anatomical characters. Differences between species and species groups in the southern African species appear to be as great as differences between taxa of much higher rank elsewhere in the Poaceae. Overseas workers who have examined only a few taxa may have erroneously concluded that they are representative of the entire genus or tribe. This wide range of variability may be a result of the early divergence of the Ehrharteae from other grasses, as suggested by the ancient Gondwanaland distribution pattern.

The representatives of *Ehrharta* in southern Africa may help to provide a better understanding both of the history of the flowering plants and of the early evolution of the Poaceae. They will therefore be treated in some detail. We propose to set out the species groups informally in this introductory paper, and thereafter to publish a parallel series of papers covering the taxonomy and anatomy of each species group. A concluding paper will present a formal generic and infrageneric classification and will develop hypotheses about the phylogeny of the species groups, and their phytogeographical significance.

MATERIALS AND METHODS

For the morphological investigations, herbarium specimens were examined from BOL, JF, K, NBG, PRE, SAM and STE. The PRE material includes the anatomical voucher specimens of Ellis, described below. Field observations were made for about 30 of the taxa. Spikelets were dissected without special preparation, and were observed with a dissecting microscope.

For the anatomical investigations, specimens of *Ehrharta* plants were collected in the field throughout South Africa during the period 1974 to 1984. A total of 160 specimens were collected representing most of the taxa recognized in this genus. This sample was designed to incorporate considerable morphological and geographical variation in many taxa. Herbarium voucher specimens were prepared for identification by the National Herbarium (PRE) after segments of leaf blade material had been removed and fixed in FAA (Johansen 1940).

Transverse sections, 10 μ m thick, were prepared after desilicification in 30% hydrofluoric acid (Breakwell

1914), dehydration using the method of Feder & O'Brien (1968) and infiltration and embedding in Tissue Prep (Fisher Scientific). The sections were stained in safranin and fast green (Johansen 1940). The manual scraping method of Metcalfe (1960) was used to prepare scrapes of the abaxial epidermis. These were either double-stained in methylene blue and ruthenium red or only in safranin. The anatomical detail was recorded photographically using a Reichardt Univar microscope and Ilford Pan F film (ASA 50).

The material fixed in FAA was also used for ultrastructural studies with a scanning electron microscope. The leaf blade segments were dehydrated in 2,2-dimethoxypropane (Merck) for 2 hours and then placed in 100% acetone for 5 minutes following the method described by Neumann, Rushing & Mueller (1982). The material was critical point dried with liquid CO₂ at 85 atmospheres at 40° C after which it was mounted on aluminium stubs with double sided tape. It was then glow discharge coated with a thin ($\pm 400 \text{ \AA}$) layer of metallic gold in a sputter coater. Preparations were either stored in a dessicator with silica gel or observed directly with an ISI SX-25 scanning electron microscope operated at 25 Kv accelerating voltage. Cuticular structure was photographed with a 6 × 7 cm camera on Ilford FP4 120 film at varying magnification.

HISTORICAL BACKGROUND

The classification of Ehrharta within the Poaceae

The placement of *Ehrharta* in the grass family has varied at both the tribal and subfamilial level (Table 1). Most older systems, based only on spikelet morphology, place *Ehrharta* in Phalarideae because of the two sterile florets below the single fertile floret. Modern treatments based on a number of cryptic characters place the genus in a tribe of its own, Ehrharteae. Although first distinguished as an entity by Link (1827), his authorship of the name cannot be accepted for nomenclatural reasons (Willemse 1982). Thus, Nevski (1937) is the recognized author for Ehrharteae, which was also described in error as new by Tateoka (1957). Nees (1841), in the earliest treatment of southern African grasses that adopted a suprageneric classification, placed *Ehrharta* in the Oryzae, although Trinius (1839), working in co-operation with Nees, had earlier placed it in the Phalarideae, where it remained until the modern system of Stebbins & Crampton (1961), who placed the tribe back into the Oryzoideae.

Although there is now agreement on tribal composition, the question of subfamily classification is not yet settled. The most recent treatments include Ehrharteae in Bambusoideae (Renvoize 1985; Watson *et al.* 1985), but both discuss the difficulty of including Ehrharteae in the subfamily as they constitute it. Renvoize (1985) states that there is no clear correlation between anatomical and other characters, such as embryo type and lodicules, and Watson *et al.* (1985) indicate that, although they decided to treat the group as bambusoid, other numerical analyses either place it as arundinoid or lose it altogether. Soderstrom & Ellis (in prep.), who classify bambusoid genera and allies, place the Ehrharteae outside the Bambusoideae, closer to Arundinoideae.

This confused situation may be explained partly

because, as Table 1 indicates, the modern subfamily classifications are based on a very small set of data derived from only a few species. In this century, only Tateoka (1963) has examined more than three taxa, and only four taxa in all have been examined either for chromosomes, embryos or leaf blade anatomy. The detailed study of the southern African taxa of *Ehrharta* presented in this and following papers should provide the breadth of information needed to indicate the natural affinities of this fascinating but baffling genus.

The southern African species of Ehrharta

The study of African *Ehrharta* falls into three phases, which correspond roughly to the 18th, 19th and 20th centuries. The earliest phase was characterized by the description of species in four different genera. L. C. M. Richard (1779) described *Trochera striata*, and a few months later Thunberg (1779) described *Ehrharta capensis*. These names were based on different types but represent the same taxon. Soon after, Linnaeus (1791) described two more species, but placed them in the genus *Aira*. Lamarck (1786), J. E. Smith (1789, 1790) and J. F. Gmelin (1791) each described species in Thunberg's genus *Ehrharta*. However, Thunberg himself (1794) accounted for his specimens collected from the Cape in *Melica*, so that his *Prodrum plantarum capensium* treatment comprised two genuine *Melica* species and four species of *Ehrharta*.

The second phase, one of consolidation, began in the next century with Swartz's (1802) thorough and beautifully illustrated study of the genus, in which he recognized nine species, each with synonyms. He described no new taxa, but moved Thunberg's 'Melicas' to *Ehrharta*. He was aware of, but did not take up, *Trochera* as the name for the genus. He also did not always follow priority of publication in applying the specific epithets, although his synonymy within each species is otherwise sound. Palisot de Beauvois (1812) alone took up the name *Trochera*, to which he attributed two species.

Schrader (1821) covered 17 species, including all those in Swartz's (1802) treatment as well as eight new species that were based on the specimens of Hesse. He was the first to divide the genus into sections, distinguishing two entities on the character of bulbous versus fibrous 'roots'. Although published two years later, Thunberg's (1823) *Flora capensis* treatment was merely a summary of Swartz (1802), and did not include Schrader's species. During this period of consolidation, a few new species were described by Kunth (1829), by Schultes (1830) and by Steudel (1853).

Most ambitious of the nineteenth-century studies of *Ehrharta* were those of Nees & Esenbeck (1832, 1839, 1841). His *Florae Africae Australioris* (1841) recognized 25 species, of which nine were described by him, using collections of Drège and Ecklon. Nees also put forward a multitude of varieties (nine in *E. calycina* alone), which, however were not validly published because he did not consistently apply Articles 24–27 of the ICBN (Linder 1985). He adopted Schrader's basic division of the genus by 'root' type, and in addition subdivided the fibrous-rooted species according to size and hairiness of the sterile lemmas. These subdivisions are

TABLE 1.—Subfamily and tribal classifications of *Ehrharta* by various authors

Treatment	Subfamily or series	Tribe	Characters emphasized	Taxa examined
Nees (1841) also Steudel (1855)		Oryzeae	Spikelet 1-flowered; Stamens 6	25 species
Bentham (1883) also Stapf (1900, 1917) Hackel (1887) Hubbard (1973)	Poaceae	Phalarideae	Spikelet deciduous above glumes; bisexual flower 1, terminal	<i>E. longiflora</i>
Avdulov (1931)	Series B (= Festucoid)	Oryzeae	Chromosomes	<i>E. erecta</i>
Pilger (1954)	Festucoideae	Phalarideae	Numerous spikelet and cryptic characters	Not stated
Reeder (1957)	'Oryzoid-Olyroid type'		Embryos	1 species, not named
Tateoka (1957, 1963)	Arundinoideae	Ehrharteae	Leaf blade anatomy	19 species
Prat (1960)	'Genre a position discutée'			
Metcalfe (1960)	'Intermediate between panicoid and festucoid'		Leaf blade anatomy	<i>E. erecta</i> <i>E. villosa</i> var. <i>maxima</i>
Stebbins & Crampton (1961)	Oryzoideae	Ehrharteae	Not stated	Not stated
Jacques-Felix (1962)	Ehrhartoideae	Ehrharteae	Spikelets, chromosomes, leaf blade anatomy	<i>E. erecta</i> <i>E. calycina</i>
Clayton (1970)	(Bambusoid)	Ehrharteae	Embryo	<i>E. erecta</i>
Clifford & Watson (1977)	Undefined residue		300 spikelet, morphological and cryptic characters	Not stated
Renvoize (1981)	Arundinoideae	Ehrharteae	Leaf blade anatomy	Not stated
Renvoize (1985)	Bambusoideae	Ehrharteae	Leaf blade anatomy	<i>E. calycina</i> <i>E. erecta</i> <i>E. dura</i>
Watson <i>et al.</i> (1985)	Bambusoideae (Oryzaneae)		300 spikelet, morphological and cryptic characters	Not stated

still recognized, although a number of the species have been re-aligned.

The last of the comprehensive nineteenth-century accounts of *Ehrharta* was that of Steudel (1853). He compiled the species known at that time, 32 in all for southern Africa. Of greatest significance is his basic division of these species into two groups, not by the possession of a bulbous base, as previously, but by the separation of *E. setacea* and *E. rupestris* into a group ('Racemosae') distinct from the rest of the species ('Paniculatae'). It is unfortunate that he did not elaborate on the characters on which he based his decision, because this fundamental division in *Ehrharta* is supported by the present study. After 1855, no further work was done in the genus except that Kuntze (1891), rediscovering the priority of the genus name *Trochera*, transferred all the then-accepted taxa to *Trochera*.

The third phase in the taxonomic study of *Ehrharta* has been dominated by Stapf's (1900) *Flora capensis* treatment, which is the most recent critical study of the southern African taxa. He also recognized 25 species, of which six were newly described by him, and he placed a number of previously recognized species into synonymy. Chippindall (1955) adopted Stapf's concepts, only making changes in the keys and stressing close relationships between some of Stapf's taxa. She included a new species of C. E. Hubbard (1933), but omitted that of

Mez (1921). Since 1955, new taxa have been described by Launert (1961) and Gibbs Russell (1984a, 1984b).

Stapf did not follow Kuntze (1891) in taking up the name *Trochera*, and soon after the conservation of generic names was permitted, *Ehrharta* of Thunberg was conserved over *Trochera* of L. C. M. Richard, which was rejected in ICBN (Voss *et al.* 1983).

TAXONOMIC CHARACTERS

The taxa described by previous workers can be grouped into seven easily recognizable groups on the basis of morphological and anatomical characters as shown in Table 2. A brief discussion of those characters found to be useful in this regard follows.

Morphological characters

1. Macromorphological characters

For a genus of moderate size, *Ehrharta* has a wide range of macromorphological characters, a selection of which are shown in Table 2. They are reasonably well known, from the detailed descriptions of Stapf (1900) and the briefer but more image-creating descriptions of Chippindall (1955). However, unless the species are placed in groups based on spikelet morphology and leaf blade anatomy, the diversity of vegetative characters is confusing. With these groupings, it can be seen that

TABLE 2.—Morphological and anatomical characters used to differentiate species groups in *Ehrharta*. Each group is referred to by the name of a widespread species that exhibits the characters of the group

	Setacea							Capensis							Erecta					Calycina							Villosa			Ramosa				Dura			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35		
MORPHOLOGY																																					
1. HABIT: Annual (A) Perennial (P)	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A	(A) P	(A) P	(A) P	A	P	A	A	A	P	A	P	P	P	P	P	P	P	P	P	P		
2. CULMS: Suffrutescent (S) Herbaceous (H)	S		S (H)	S		S	S	H	H	H	H	H	H	S	H	H	H	H	H	H	H	H	H	H	H	H	S	S	S	S		H	H	H	H	H	
3. INTERNODES BULBOUS (B)								B	B	B	B	B	B														(B)			(B)			(B)				
4. LEAF LIGULES: Glabrous (G), Ciliate (H)	H	H	H	H	H	H	H	H	H	H	H	H	H	H	G	G	G	G	G	H	G	G	G	H	G	G	H	H	H	H	H	H	H	G	G		
5. LEAF BLADES: Setaceous, rolled, folded (S) Reduced or absent (R)	S		S	S		S	S	S						(R)													S R	S R	S R	S R	S	S	S	S	S		
6. SPIKELET NUMBER	4-8	1-2	5-9	5-15	1-4	5-17	1-2	∞	∞	∞	∞	∞	<35	<40	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	<40	<40	<20	1-5	∞	∞	
7. SPIKELET LENGTH (mm)	4-6	4-5	4-6	6-8	4-7	7-8	4-5	10-12	8-10	7-12	7-10	7-10	9-13	10-13	4-12	3-4	4-5	5-8	2-4	3-5	2-3	3-5	2-3	4-9	5-9	3-4	10-14	11-14	14-18	6-9	6-8	7-8	5-7	13-15	9-17		
8. GLUME/SPIKELET LENGTH	1/3	1/3	1/3	2/3-7/8	≅	2/3-3/4	≅	1/2-2/3	1/2-2/3	1/3-1/2	1/2	1/2	1/3	2/3-3/4	1/3	1/2-2/3	1/2-2/3	1/2-2/3	1/2	>	2/3-3/4	≅	≅	2/3-≅	≅	≅	1/2-3/4	3/4	≅	≅	2/3-≅	≅	>	1/3-1/2	1/3-1/2		
9. 1st STERILE LEMMA: Reduced (R), ≅ 2nd st. lemma (2)	R	R	R	R	R	R	R	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
10. 2nd STERILE BASE: Constricted (C) Stipitate (S) Appendages (A)								S	S	C (S)	C S	C S	S	(S)	C S	C	C	C	C		C	C			C	S	S	S	S		A	A	A	A			
11. STERILE LEMMA TEXTURE: Smooth (S) Rough (R)	R	R	R	R	R	R	R	R	R	R	R	R	R	R	(S) R	S		R	R	R			S	S	S	S	S	S	S	S	R	R	R	R	R	R	
12. STERILE LEMMA SIDES: Glabrous (G) Hairy (H)	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G		H	H	H	H	G	H	H	H	G	G	G	G	G	G	
13. STERILE LEMMA BASES: Glabrous (G), Bearded (B)	G	G	G	G	G	G	G	B	B	B	B	B	B	B	B	G	B	B	B	G	G	G	?	?	?	?	G	B	B	B	B	B	B	B	B	B	
14. STERILE LEMMA TIPS: Mucronate (M), Awned (A)								M		M	M	M	M	M	A				A		M	M		M	A		M	M	M					A	A		
LEAF ANATOMY																																					
1. MIDRIB AND KEEL: Keel absent (A) Keel present (P)	A	A	A	A	A	A	*	*	A	P	P	*	*	A	P	P	P	*	P	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	*		
2. ADAXIAL RIBS: Absent (A) Slight (S), Large (L), Massive (M)	L	L	L	L	L	L	*	*	M	A	A	*	*	A	S	(A) S	S	*	S	S	A	A	(A) (S)	S	(A) S,L	S	S,L	S,L	S,L	S,L	(S) (S)	(S) (S)	(S) (S)	A	L	*	
3. MESOPHYLL: Arm cells (A) Compact isodiametric (B) Compact angular (C) Diffuse irregular (I)	A	A	A		A	A	*	*		C	C	C	*	*	C	I	I	I	*	I	C	I	C	C	C	C	C	C	C	C	(B) C	B	(B) C	B	C	*	
4. EPIDERMAL ZONATION: Differentiated (D) Undifferentiated (U)	U	U	U	U	(D) U	U	(D) U	*	U	D	D	*	*	D	D	D	D	*	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
5. INTERCOSTAL LONG CELLS: Hexagonal length (μ) Rectangular (R) Sinuous walls (S) Straight walls (W)	<10	<10	<10	<10	<10	<10	<10	*	<10	10-20	10-20	*	10-20	10-20	>20	>20	>20	*	>20	10-20	>20	>20	>20	>20	>20	>20	>20	>20	>20	10-20	R S	R S	R S	R S	R S	R S	
6. STOMATA: Absent (A) Wax bodies present (P), absent (X) Epidermal flanges (E)	A	A	A	A		X	A	*	A	P	P	*	*	*	P	P	P	*	*	*	P	P	P	P	*	P	X E	X E	X E	X	*	X	X	X	P	*	
7. SILICA BODIES: Paired (P), Short rows (S) Rounded (R) Dumbell (D)	P	P	P	P	P	P	P	*	P	P	P	*	P	P	S D	S D	S D	*	S D	S D	S D	S D	S D	S D	S D	S D	P R	P R	P R	P	P	P	P	P	P	*	
8. PRICKLES: Hook-like (H), Macrohair-like (M)	H	H	H	H	H	H	H	*		H	H	*	M	M	M	M	M	*	H,M	M	H,M	H,M	H,M	H,M	H	M	H			H	H	H	H	H	*		
9. MICROHAIRS: Distal cell truncated (X), not tapering (Y), tapering (Z)	X	X	X	X	Y	X	X	*		Z	Z	*	*	Z	Z	Z	Z	*	Z	*	Z	Z	Z	Z	*	Z	Z	*	*	Y	Y	Y	Y	Y	*		
10. EPICUTICULAR WAX: Present (P), Absent (A)	P	P	P	A	P	A	*	*	A	P	P	*	*	P	P	P	P	*	P	*	P	P	P	P	*	P	P	*	*	P	P	P	P	P	*		

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there are a few parallel trends that occur in several species groups, and that a number of differences in structure are associated with each trend. For example, suffrutescence occurs in four of the species groups (Setacea, Capensis, Gigantea and Ramosa), and involves, in each group, long branched rhizomes, much branched culms that serve as the main photosynthetic organ, and reduction of leaf blades.

a. *Habit* in the majority of *Ehrharta* species is perennial, but several are annual. The annual habit seems related to unpredictable moisture availability. All the annual species, except one, occur in the drier north-western part of the range of the genus, centred on the Succulent Karoo, from about Clanwilliam north to southern SWA/Namibia. These species fall only in the Erecta and Calycina groups, and each has closely related perennial species in the more mesic central part of the distribution of the genus. The other annual species, *E. longiflora*, grows in seasonally wet places, and it has, for an *Ehrharta*, a wide distribution, occurring not only in arid areas to the northwest, but as far east as Port Alfred. It is the only species in which the spikelet morphology is not consistent with the leaf blade anatomy.

b. *Rhizomes* occur in all perennial species, but the form of the rhizome varies widely, and is correlated with the substrate. Species that grow between rocks have tough, branched, naked rhizomes that are hardly different from the lower part of the culm. These rhizomes can creep for several meters in deep cracks, so that the plant forms a dense linear cushion. Species that occur in sand have long branching rhizomes that run 0.3 m or more below the soil surface and send up culms at the tips, so that a single plant can appear to be a loose colony several meters across. These rhizomes may be naked or densely clothed by hairy cataphylls. Species that grow in clay or loam soils usually have short knotted rhizomes that do not spread far away from the base of the individual plant, although in a few species unbranched rhizomes a few centimeters long and with papery cataphylls may occur.

c. *Culm* characteristics are the most important in determining the overall appearance of a grass plant, and in *Ehrharta* the culms are very diverse. In different taxa the culms vary from solitary to numerous, from herbaceous to wiry or woody, from erect to procumbent, from unbranched to simply or verticillately branched. Length varies between taxa from less than 100 mm to over 1.5 m in flowering individuals.

Taxa in the Capensis groups have the lowest (sometimes the two lowest) internodes modified into an extremely hard cylindrical or globose bulb-like structure. The occurrence of this 'bulb' may be associated with the periodic fires in the fynbos. 'Bulbous' species are much in evidence for a year or two after a fire, but apparently do not occur in long-unburned situations. However, immediately following the next burn, flowering plants may be found with many old dead 'bulbs' hidden underground, indicating that the plant is several years old, having survived the fireless period in this form.

Stolons are known only in a local limestone variant of the widespread species *E. calycina*.

d. *Leaves*, as in other grasses, are composed of sheath, ligule and blade. The sheaths are split to the base

and usually cylindrical, or rarely keeled. In some species the upper sheaths may be longer than the internodes, so the leaves are closely imbricate. In suffrutescent species with reduced leaf blades the sheaths may be persistent around the culm, or be held outward at an angle, or they may be lost. The basal sheaths may be persistent, densely clothing the base of the culm, or they may slip away from the culm with age, leaving it exposed. A few taxa may be distinguished by a characteristic colour of the basal sheaths.

The ligules are short, usually less than 3 mm long, and take the form of a ciliate rim in all species groups except the Erecta and Calycina groups, in which most taxa have glabrous ligules.

The leaf blades vary from broad and flat, often with one or both margins with a heavy undulate marginal vein, to folded, rolled, setaceous or absent. Length varies between taxa, from less than 100 mm to over 1 m. Loss or reduction of leaf blades is correlated with suffrutescence. In these taxa, the phenology of leaf blade development should be studied in the field, because it is possible that striking differences in appearance may be due to the age of a plant rather than to genetic differences.

e. *Inflorescences* are most commonly paniculate, but in some taxa may be reduced to a raceme with few spikelets, and there is often a tendency for the narrower inflorescences to be secund. Generally the inflorescence is exserted far above the highest leaf sheath, but in a few taxa (especially annuals) it is closely subtended or even enveloped below by an inflated leaf sheath. In some taxa with racemose inflorescences the main axis curves sinusously around the appressed spikelets.

2. Spikelet morphology

The spikelets are usually laterally compressed, although in some taxa the sides are rounded. At maturity, the spikelet is shed as a unit above the glumes, which are persistent on the pedicel. A spikelet consists of a pair of glumes, two empty sterile lemmas, and, at the tip of the rachis, a fertile floret composed of lemma, palea and bisexual flower. Each species group has a characteristic range of spikelet sizes.

a. *Glumes* are subequal, and may be shorter than, equal to or longer than the whole spikelet, and relative glume length is a useful character for distinguishing between species in a group. The glumes are more papery in texture than the lemmas, and are unornamented.

b. *Sterile lemmas* are the single most striking spikelet feature of *Ehrharta*. Their curious sculpturing in some species is unknown elsewhere in the grass family, and renders a detached spikelet immediately recognizable. Shape, relative size and ornamentation of the sterile lemmas are the most useful characters in separating the species groups. In three of the species groups, Erecta, Calycina and Dura, the tips of the sterile lemmas can have long awns, and in the Capensis and Villosa groups the bases are shortly stipitate. In most *Ehrhartas* the sterile lemmas are of similar size and the smaller fertile lemma differs from them, but in the Setacea group the first sterile lemma is short and glume-like and the fertile lemma is similar to the second sterile lemma.

The lemma surfaces may be dull or shining, scabrous or smooth. The sides and margins may be glabrous or have hairs of various lengths, and the bases may be glabrous or bearded. The bases of the second sterile lemma and the fertile lemma come together in a hinge-like joint that resembles an earlobe, and which may have a membranous appendage. All these characteristics are used in separating the species groups. Differences in transverse and longitudinal ribs and veins distinguish species within the groups.

c. *Fertile florets* have a lemma that is smaller and more laterally compressed than the sterile lemmas, and is unornamented. The palea is sickle-shaped or straight, is much smaller than the lemma and is usually hidden within it. The fertile florets of most species are similar, and are not useful for distinguishing species or groups.

d. *Flower structure* is remarkable in *Ehrharta* because of the presence of six stamens in most species, although some of the taxa with small spikelets may have five, four, three or one stamens. The two lodicules are relatively large and flat, and are usually ovate or 2-lobed.

e. *Caryopsis* information for comparison is lacking because of the small number of spikelets that are found to have mature fruits. It appears that the spikelet is shed as soon as the fruit is mature. The lack of this information, as well as data about embryos, is a serious defect in our knowledge of the genus.

Anatomical characters

A suite of leaf blade anatomical characters separate and define the various species groups in *Ehrharta*. These cryptic features are manifested in the leaf blade as seen in transverse section, in the abaxial epidermis in surface view and ultrastructurally (Table 2). Some of these characters distinguishing the species groups recognized in *Ehrharta* are generally considered to be features of high taxonomic value, important at the subfamily level in the Poaceae. In *Ehrharta*, however, they separate taxa below the generic level. Examples are differences in mesophyll structure and microhair shape.

The 10 characters which were scored for all the southern African *Ehrharta* taxa are diagrammatically represented in Table 4. This suite of anatomical characters in combination serves to define and diagnose each of the seven species groups as well as two subgroups within one of the groups. The variation encountered in most of the characters in most of the groups will be fully described and discussed in subsequent papers. The character states used to define each of the groups here are, therefore, somewhat generalized and may vary within certain limits and intergrade between certain groups. In the cases where variation was observed, definite lines of development could be traced and the variation could usually be interpreted on this basis.

1. Midrib or keel

The vascular structure of the keel or midrib is an important character in grass taxonomy at the subfamily level. Complex vasculature of the keel would definitely support bambusoid affinities as suggested by many authors. This type of keel does not occur in any of the species groups from South Africa but the presence of only a median vascular bundle or the presence of a definite keel with additional parenchyma tissue differs

between the species groups recognized, and only varies within the Calycina group.

2. Ribs and furrows

Adaxial ribs and furrows, particularly the massive ribs of the Longifolia group, distinguish certain groups. The raised, inflated abaxial epidermal cells in the mid-intercostal zones of the Calycina group are diagnostic and of considerable phylogenetic interest because this characteristic is shared with the Phalarideae with which the Ehrharteae has been linked by earlier authors. These epidermal cells are also evident in the epidermis as seen in surface view.

3. Mesophyll

The chlorenchyma cells of *Ehrharta* are surprisingly variable in structure and arrangement. In the Setacea group arm cells definitely are present in some taxa. This is a bambusoid characteristic but is also known in some taxa without bambusoid or oryzoid affinities (Watson *et al.* 1985). In some groups the chlorenchyma cells are compact and angular with minute air spaces but, in other groups this tissue is very diffuse, of irregular, rounded cells with air spaces clearly visible. In the Villosa group the abaxial layer of chlorenchyma is very regular and almost palisade-like.

4. Epidermal zonation

Some groups are distinguished by costal and intercostal zones on the abaxial surface. Zonation is not evident in the Setacea and Longifolia groups and this is associated with an absence of abaxial stomata as observed in these two groups. This lack of zonation appears to be associated with the ecological conditions of the Mountain Fynbos with very low soil nutrition and also occurs in many of the danthonoid grasses from the same habitats. Species from the Lowland Fynbos, on the other hand, have clear epidermal zonation and abaxial stomata. These characters tend to vary in groups which have a wide ecological tolerance and occur in both these two major habitat types.

5. Intercostal long cells

Hexagonal or inflated but rather short long cells with sinuous walls distinguish some groups, whereas others have elongate, fusiform, hexagonal intercostal long cells with straight walls. In the Calycina group with this latter type of long cell, the mid-intercostal cells are much longer than the lateral ones and these cells are also the raised, inflated cells as seen in transverse section. In other groups the intercostal long cells are rectangular with sinuous walls.

6. Abaxial stomata

The stomata of the various species groups of *Ehrharta* are also of taxonomic interest. They may be absent on the abaxial surface, as in the Longifolia group and in many taxa of the Setacea group. In the Capensis group the guard cells are clearly visible but the subsidiary cells are covered with wax platelets, as seen with the scanning electron microscope. In the Erecta group the stomata are often obscured by large, solid wax plugs, whereas, in the Calycina group cubical wax granules often overlie the stomata. In the Villosa group the stomata are sunken and overarched by four characteristic papilla-like flanges from the adjoining long cells. In the Ramosa group the

stomata have no associated wax deposits whereas in the Dura group the pores are obscured by dense accumulations of wax platelets. Stomatal structure, and associated epicuticular wax, therefore, serves to distinguish all but two of the species groups in *Ehrharta* and provides useful characters at the species level. The low dome-shaped subsidiary cells, which are present throughout *Ehrharta*, are typical of, but not exclusive to, the Arundinoideae (Renvoize 1981).

7. Costal silica bodies

The silica bodies of *Ehrharta* are somewhat variable and rather difficult to use as diagnostic characters. Single, rounded, or paired bodies characterize some groups whereas in others this type of body is more dumbbell-shaped. In the Erecta and Calycina groups the costal silica bodies are in short chains and of the dumbbell type but this shape can only be determined by varying the focus. Silica body shape and arrangement is often a character differentiating taxa at higher taxonomic levels than that of genus.

8. Prickles

The costal macrohair-like type of prickle hair is only found in the Erecta and Calycina groups. This type of hair is common in the pooid and bambusoid grasses but is much rarer in the arundinoids. In the other species groups of *Ehrharta*, only shortly barbed prickles occur, except in the Longifolia subgroup of the Capensis group where prickle hairs are absent.

9. Microhairs

Microhairs in *Ehrharta* are very small and difficult to observe with the light microscope. However, they are clearly visible with the SEM and clear differences between the species groups are visible. The hairs may have short, truncated distal cells or this cell may taper to an acute apex. The length of the hairs also differs between the species groups. The Longifolia subgroup is the only grouping that does not possess abaxial microhairs. Microhair shape is a very important character separating the subfamilies of the Poaceae and the degree of variation observed in *Ehrharta* is most unusual.

10. Epicuticular wax

The occurrence and nature of the epicuticular wax deposits also appears to be a useful taxonomic character in *Ehrharta*, serving to distinguish between the species groups. The wax may be absent or present either as fine rods or as heavier platelets. The significance of this wax as a feature of higher taxonomic application is unknown.

The suite of leaf anatomical characters used to distinguish the species groups in *Ehrharta*, therefore, includes a wide spectrum of attributes and, in combination, these features serve to assign any given specimen to a particular group. However, it is not easy to identify to the species level using leaf anatomical criteria because the species are not so distinct anatomically. Nevertheless, the recognition and definition of the seven groups of species in this very difficult genus will definitely help in providing new insights into the phylogenetic relationships of the genus, until such time as sufficient embryo and chromosome data are available.

OUTLINE OF SPECIES GROUPS

Each of the species groups in *Ehrharta* can be described on the basis of a set of morphological and anatomical characters as summarized in Tables 3 & 4 respectively. A brief synopsis of characters and diagnosis is then given for the constituent taxa of each group.

SETACEA GROUP

Included taxa (Gibbs Russell 1984)

- E. rupestris* Nees ex Trin.
 - subsp. *rupestris*
 - subsp. *tricostata* (Stapf) Gibbs Russell
 - subsp. *dodii* (Stapf) Gibbs Russell
- E. setacea* Nees
 - subsp. *setacea*
 - subsp. *scabra* (Stapf) Gibbs Russell
 - subsp. *uniflora* (Burch. ex Stapf) Gibbs Russell
 - subsp. *disticha* Gibbs Russell

Morphological description

1. Perennial.
2. Culms herbaceous or suffrutescent.
3. No parts bulbous.
4. Leaf ligules ciliate.
5. Leaf blades expanded in herbaceous taxa, either setaceous or folded in suffrutescent taxa.
6. Spikelets fewer than 20.
7. Spikelets 4–8 mm long.
8. Glumes one third to almost equalling lemma length.
9. First sterile lemma reduced and glume-like, with veins.
10. Second sterile lemma base not stipitate, lacking appendages.
11. Sterile lemma surface rough.
12. Sterile lemma sides glabrous.
13. Sterile lemma bases not bearded.
14. Sterile lemma tips awnless, not mucronate.

Anatomical description

1. No keel developed; only median vascular bundle present.
2. Adaxial ribs and furrows present; ribs rounded and well developed (except in *E. setacea* subsp. *disticha* and subsp. *uniflora*).
3. Mesophyll compact, of small rounded or isodiametric cells; tendency for arm cell-like invaginations in all taxa; *E. setacea* subsp. *scabra* with typical bambusoid-like arm cells.
4. Costal and intercostal zones not differentiated (except in those species with abaxial stomata — *E. setacea* subsp. *disticha* and subsp. *uniflora*).
5. Intercostal long cells inflated to hexagonal; short, less than 20 μ m long (usually less than 10 μ m long); with sinuous walls.
6. Abaxial stomata absent (except in *E. setacea* subsp. *disticha* and subsp. *uniflora* and then without wax platelets).
7. Costal silica bodies single or paired or absent; rounded.
8. Costal and intercostal prickles present; either hooks or asperities with very short barbs; absent in *E. setacea* subsp. *disticha* and subsp. *uniflora*.
9. Microhairs with short, truncated distal cell; longer in *E. setacea* subsp. *disticha* and subsp. *uniflora*.
10. Epicuticular wax either absent or as fine rods.

Distinguished by:

First sterile lemma reduced, glume-like. Spikelets fewer than 20. Arm cells present.

CAPENSIS GROUP

Included taxa (Gibbs Russell 1984a; Smook & Gibbs Russell 1985)

- E. longifolia* Schrad.
- E. ottonis* Kunth ex Nees

TABLE 3.—Morphological characters diagnostic for the species groups in *Ehrharta*

	SETACEA	CAPENSIS		ERECTA	CALYCINA	VILLOSA	RAMOSA	DURA
		LONGIFOLIA	CAPENSIS					
HABIT	PERENNIAL	PERENNIAL	PERENNIAL	ANNUAL OR PERENNIAL	ANNUAL OR PERENNIAL	PERENNIAL	PERENNIAL	PERENNIAL
CULMS	SUFFRUTESCENT OR HERBACEOUS	HERBACEOUS	HERBACEOUS (r. suffrutescent)	HERBACEOUS	HERBACEOUS	SUFFRUTESCENT	HERBACEOUS (r. suffrutescent)	HERBACEOUS
INTERNODES	THIN	LOWEST BULBOUS	LOWEST BULBOUS (r. thin)	THIN	THIN	(rhizome subbulbous)	(upper with bulbous galls)	THIN
LEAF LIGULES	CILIATE	CILIATE	CILIATE	GLABROUS	GLABROUS	CILIATE	CILIATE	GLABROUS
LEAF BLADES	SETACEOUS OR EXPANDED	EXPANDED OR SETACEOUS	EXPANDED	EXPANDED	EXPANDED	REDUCED	REDUCED OR SETACEOUS	SETACEOUS OR EXPANDED
SPIKELET NUMBER	FEW	MANY	MANY	MANY	MANY	MANY	FEW	MANY
SPIKELET SIZE	SMALL	LARGE	LARGE	SMALL	SMALL	VERY LARGE	SMALL	VERY LARGE
GLUME LENGTH	SHORT OR LONG	SHORT	SHORT	SHORT	LONG	LONG	LONG	SHORT
FIRST STERILE LEMMA	REDUCED	EQUALLING 2nd	EQUALLING 2nd	EQUALLING 2nd	EQUALLING 2nd	EQUALLING 2nd	EQUALLING 2nd	EQUALLING 2nd
SECOND STERILE LEMMA BASE	STRAIGHT	STIPITATE	STIPITATE	CONSTRICTED	APPENDAGED	STIPITATE	APPENDAGED	STRAIGHT
STERILE LEMMA TEXTURE	ROUGH	ROUGH	ROUGH	ROUGH OR SMOOTH	SMOOTH	SMOOTH	ROUGH	ROUGH
STERILE LEMMA SIDES	GLABROUS	GLABROUS	GLABROUS	GLABROUS	HAIRY OR GLABROUS	HAIRY	GLABROUS	GLABROUS
STERILE LEMMA BASES	GLABROUS	BEARDED	BEARDED	BEARDED OR GLABROUS	GLABROUS OR ??	BEARDED	BEARDED	BEARDED
STERILE LEMMA TIPS	ROUNDED	MUCRONATE	MUCRONATE	ROUNDED OR AWNED	MUCRONATE OR AWNED	MUCRONATE	ROUNDED	AWNED

E. barbinodis Nees ex Trin.*E. capensis* Thunb.*E. bulbosa* J. E. Sm.*E. eburnea* Gibbs Russell**Morphological description**

1. Perennial.
2. Culms herbaceous (except *E. barbinodis* where they are suffrutescent).
3. Culm base bulbous at lowest internode (except *E. barbinodis*).
4. Leaf ligules ciliate.
5. Leaf blades expanded or rolled (but very short in *E. barbinodis*).
6. Spikelets many (but less than 35 in *E. eburnea*).
7. Spikelets 7–13 mm long.
8. Glumes $\frac{1}{3}$ – $\frac{3}{4}$ lemma length.
9. First sterile lemma not reduced, lacking veins.
10. Second sterile lemma base stipitate, lacking appendages.
11. Sterile lemma surface rough.
12. Sterile lemma sides glabrous.
13. Sterile lemma bases bearded.
14. Sterile lemma tips awnless, mucronate.

Distinguished by:

Lowest culm node bulbous (except *E. barbinodis*). Second sterile lemma stipitate. Spikelets large, 7–13 mm long, hairy at margins.

Anatomical description

Anatomically this group cannot be defined satisfactorily as the taxa included vary greatly in anatomy. Nevertheless, two distinct and anatomically homogeneous subgroups can be distinguished and these will be dealt with separately.

LONGIFOLIA SUBGROUP**Included taxa** (Smook & Gibbs Russell 1985)*E. longifolia* Schrad.*E. ottonis* Kunth. ex Nees**Anatomical description**

1. Keels absent; median vascular bundle undifferentiated from lateral first order vascular bundles.
2. Massive adaxial ribs and deep, cleft-like furrows with interlocking prickles.
3. Mesophyll compact, of large angular cells; in U-shaped groups occupying the sides and bases of the furrows.

TABLE 4.—Anatomical characters diagnostic for the species groups in *Ehrharta*

SPECIES GROUPS	SETACEA	CAPENSIS		ERECTA	CALYCINA	VILLOSA	RAMOSA	DURA
		LONGIFOLIA	CAPENSIS					
KEEL AND MIDRIB								
RIBS AND FURROWS								
MESOPHYLL CELLS								
EPIDERMAL ZONATION	NOT PRESENT	NOT PRESENT	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
INTERCOSTAL LONG CELLS								
ABAXIAL STOMATA	ABSENT	ABSENT						
COSTAL SILICA BODIES								
COSTAL PRICKLES		ABSENT						
ABAXIAL MICROHAIRS		ABSENT						
EPI-CUTICULAR WAX	ABSENT OR PRESENT	ABSENT	PRESENT	PRESENT	PRESENT	PRESENT	ABSENT	ABSENT

- 4. Costal and intercostal zones only slightly differentiated.
- 5. Intercostal long cells inflated and short; less than 10 μm long; with sinuous walls.
- 6. Abaxial stomata absent.
- 7. Costal silica bodies paired or single; rounded.
- 8. Costal prickles absent.
- 9. Abaxial microhairs absent.
- 10. Epicuticular wax absent.

Distinguished by:

Setaceous leaves without arm cells.

CAPENSIS SUBGROUP

Included taxa (Gibbs Russell 1984a; Smook & Gibbs Russell 1985)

- E. barbinodis* Nees ex Trin.
- E. capensis* Thunb.
- E. bulbosa* J. E. Sm.
- E. eburnea* Gibbs Russell

Anatomical description

- 1. Keel present comprising 1 or 3 vascular bundles (*E. capensis*) or absent (*E. barbinodis*); margin with conspicuous sclerenchyma cap.
- 2. Adaxial ribs and furrows absent.
- 3. Mesophyll semi-radiate; of compact but large, angular cells.
- 4. Costal and intercostal zones well differentiated.
- 5. Intercostal long cells elongate hexagonal, fusiform; between 10–20 μm long; with slightly sinuous walls.

- 6. Abaxial stomata present; subsidiary cells covered with wax platelets but pore visible.
- 7. Costal silica bodies single or paired; irregularly dumbbell-shaped.
- 8. Costal prickles with short barbs and intercostal prickles elongated, macrohair-like with bulbous bases.
- 9. Microhairs elongate, with tapering distal cell.
- 10. Epicuticular wax deposits as fine rods.

Distinguished by:

Presence of midrib and hexagonal long cells less than 20 μm long; stomata with wax platelets.

ERECTA GROUP

Included taxa (Smook & Gibbs Russell 1985)

- E. erecta* Lam.
 - var. *erecta*
 - var. *natalensis* Stapf
 - var. *abyssinica* (Hochst.) Pilg.
- E. triandra* Nees ex Trin.
- E. longiflora* J. E. Sm. (but spikelets similar to Capensis group)

Morphological description

- 1. Perennial or annual.
- 2. Culms herbaceous.
- 3. No parts bulbous.
- 4. Leaf ligules glabrous.
- 5. Leaf blades expanded.
- 6. Spikelets many.

7. Spikelets 3,0–7,5 mm long.
8. Glumes $\frac{1}{2}$ – $\frac{2}{3}$ lemma length.
9. First sterile lemma not reduced, veined.
10. Second sterile lemma base not stipitate, lacking appendages.
11. Sterile lemma surface rough (but smooth in some specimens of *E. erecta* subsp. *erecta*).
12. Sterile lemma sides glabrous.
13. Sterile lemma bases bearded (except in *E. erecta* subsp. *erecta* and *E. triandra*).
14. Sterile lemma tips not mucronate.
8. Glumes two thirds longer than lemma length.
9. First sterile lemma not reduced, veined.
10. Second sterile lemma base not stipitate, with ear-like appendages.
11. Sterile lemma surface smooth.
12. Sterile lemma sides glabrous or hairy.
13. Sterile lemma bases hairy (but not conspicuously bearded) in hairy taxa, but glabrous taxa not bearded.
14. Sterile lemma tips mucronate or rounded.

Anatomical description

1. Keel present; comprises one vascular bundle with ground parenchyma.
2. Very slight adaxial ribs and wide, shallow furrows present; may be absent.
3. Mesophyll rather diffuse of somewhat irregular, rounded cells; air spaces clearly visible.
4. Costal and intercostal zones clearly differentiated.
5. Mid-intercostal long cells hexagonal, fusiform in shape; elongate, more than 30 μ m long; straight-walled.
6. Abaxial stomata present; subsidiary cells always with wax deposits, often in the form of a solid plug blocking the stomatal aperture.
7. Costal silica bodies in short chains; usually dumbbell-shaped with the central part only visibly by varying focus.
8. Costal and intercostal prickles present; all taxa with the macrohair-like type of prickle; asperites sometimes occur.
9. Microhairs elongate with markedly tapering distal cell.
10. Epicuticular wax always present.

Distinguished by:

Spikelets small, and first sterile lemma well developed, and glumes short, and sterile lemmas constricted at base, lacking appendages, and lemma sides glabrous. Raised abaxial epidermal long cells absent and stomata with wax plugs.

CALYCINA GROUP

Included taxa (Smook & Gibbs Russell 1985)

- E. brevifolia* Schrad.
 var. *brevifolia*
 var. *cuspidata* Nees
E. calycina J. E. Sm.
E. delicatula (Nees) Stapf
E. longigluma C. E. Hubb.
E. melicoides Thunb.
E. pusilla Nees ex Trin.

Morphological description

1. Perennial or annual.
2. Culms herbaceous.
3. No parts bulbous.
4. Leaf ligules glabrous or ciliate.
5. Leaf blades expanded.
6. Spikelets many.
7. Spikelets 3,2–8,5 mm long.

Anatomical description

1. Keel absent, except in some specimens of *E. calycina* and *E. brevifolia* var. *cuspidata*.
2. Slight adaxial ribs and furrows; may be well developed in *E. calycina* and *E. melicoides* and may be absent in *E. calycina* and *E. brevifolia* var. *cuspidata*; raised, inflated abaxial epidermal cells always present in mid-intercostal zones.
3. Mesophyll generally compact of irregular (usually quite large), straight-walled cells; air spaces small; chlorenchyma cells often striated and refractive, possibly silicified.
4. Costal and intercostal zones clearly differentiated.
5. Mid-intercostal long cells elongated, fusiform (more than 25 μ m long); raised; with straight walls; shorter in *E. longigluma*; these cells often stain in *E. calycina* and *E. melicoides*.
6. Abaxial stomata always present; pore aperture often obscured by cubical wax granules.
7. Costal silica bodies in short chains; variably dumbbell-shaped of the type which varies in shape with differing focus.
8. Costal and intercostal prickles present; sometimes with short barbs only (*E. pusilla*) but otherwise all taxa with macrohair type of prickle.
9. Microhairs finger-like with tapering distal cell.
10. Epicuticular wax always developed.

Distinguished by:

Spikelets small, and glumes long, and first sterile lemma well developed, and second sterile lemma base not stipitate, with ear-like appendages. Raised mid-intercostal long cells and cubical wax granules associated with stomata.

VILLOSA GROUP

Included taxa (Smook & Gibbs Russell 1985)

- E. gigantea* Thunb.
E. villosa Schult. f.
 var. *maxima* Stapf
 var. *villosa*

Morphological description

1. Perennial.
2. Suffrutescent.
3. Rhizome internodes sub-bulbous (*E. gigantea*).
4. Leaf ligules ciliate.
5. Leaf blades reduced, rolled.
6. Spikelets many.
7. Spikelets 10–18 mm long.
8. Glumes one half to longer than lemma length.
9. First sterile lemma not reduced, veined.
10. Second sterile lemma base stipitate, lacking appendages.
11. Sterile lemma surface smooth.

12. Sterile lemma sides profusely hairy.
13. Sterile lemma bases conspicuously bearded.
14. Sterile lemma tips mucronate.

Anatomical description

1. Keel absent; median vascular bundle identical to lateral first order bundles.
2. Adaxial ribs and furrows present; well developed; rounded ribs of medium size.
3. Mesophyll semi-radiate of large, angular cells; abaxial layer of chlorenchyma regular and somewhat palisade-like in arrangement.
4. Costal and intercostal zones differentiated.
5. Intercostal long cells rectangular in shape; sinuous walls; sometimes mid-intercostal long cells tend to be hexagonal.
6. Abaxial stomata present; sunken and overarched by four papilla-like flanges from the adjacent epidermal cells.
7. Costal silica bodies absent or irregular in occurrence; single or paired; round in shape.
8. Prickles absent (*E. villosa*) or costal and intercostal prickles present (*E. gigantea*); hairs not macrohair-like.
9. Microhairs rather short but with tapering distal cell.
10. Epicuticular wax present but variable.

Distinguished by:

Culms over 1 m long, suffrutescent. Leaf blades reduced, rolled. Spikelets very large, lemmas profusely hairy and conspicuously bearded, stipitate, mucronate. Stomata with four epidermal flanges.

RAMOSA GROUP

Included taxa (Smook & Gibbs Russell 1985)

E. ramosa (Thunb.) Thunb.

E. rehmannii Stapf

var. *rehmannii*

var. *filiformis* Stapf

E. subspicata Stapf

Morphological description

1. Perennial.
2. Herbaceous or suffrutescent.
3. Upper internodes sometimes form bulbous galls in *E. ramosa* and *E. rehmannii* var. *filiformis*.
4. Leaf ligules ciliate.
5. Leaf blades expanded to rolled in herbaceous taxa, absent or very reduced in suffrutescent *E. ramosa*.
6. Spikelets few.
7. Spikelets 5, 5–8 mm long.
8. Glumes two thirds longer than lemma length.
9. First sterile lemma not reduced, veined.
10. Second sterile lemma not stipitate.
11. Sterile lemma surface rough.
12. Sterile lemma sides glabrous (few short hairs in *E. rehmannii* var. *rehmannii*).
13. Sterile lemma bases bearded.
14. Sterile lemma tips truncate, not mucronate.

Anatomical description

1. No keel; median vascular bundle only.
2. Ribs and furrows either absent or very slight ribs only present.
3. Mesophyll compact of small to medium, angular, isodiametric chlorenchyma cells.
4. Costal and intercostal zones differentiated.
5. Intercostal long cells rectangular but tending to hexagonal shape in mid-intercostal files in a few specimens; walls always sinuous.
6. Abaxial stomata present; no associated wax deposits; with distinct stomatal rims.
7. Costal silica bodies single or paired; irregular in shape being short dumbbell-shaped to rounded.
8. Costal and intercostal prickles present; with short to long barbs but not of the macrohair-like type.
9. Microhairs with distal cell not tapering.
10. Epicuticular wax absent.

Distinguished by:

Spikelets small, and sterile lemmas well developed, with tips rounded, sides rough and glabrous, bases glabrous and with basal appendages. Stomata with distinct rims and no wax deposits.

DURA GROUP

Included taxa (Smook & Gibbs Russell 1985)

E. dura Nees ex Trin.

E. microlaena Nees ex Trin.

Morphological description

1. Perennial.
2. Herbaceous.
3. No parts bulbous.
4. Leaf ligules glabrous.
5. Leaf blades well developed (setaceous in *E. dura*).
6. Spikelets many.
7. Spikelets 9–17 mm long.
8. Glumes $\frac{1}{2}$ – $\frac{1}{3}$ lemma length.
9. First sterile lemma not reduced, veined.
10. Second sterile lemma base not stipitate, lacking appendages.
11. Sterile lemma surface rough.
12. Sterile lemma sides glabrous.
13. Sterile lemma bases bearded.
14. Sterile lemma tips long awned.

Anatomical description

1. No keel or midrib present.
2. Well developed adaxial ribs and furrows; ribs flat-topped and furrows cleft-like.
3. Mesophyll compact, of large angular cells; air spaces not visible.
4. Costal and intercostal zones differentiated.
5. Intercostal long cells rectangular with slightly sinuous walls; tanniferous cells.
6. Abaxial stomata present; pore obscured by dense accumulation of wax platelets.
7. Costal silica bodies single or paired; irregularly dumbbell-shaped.
8. Costal prickles only; with very short barbs.

9. Microhairs very variable; with sharply tapering point or distal cell blunt; distal cell apparently not dehiscent.
10. Epicuticular wax absent except in association with the stomata.

Distinguished by:

Spikelets very large, lemmas glabrous. Plants perennial and spikelets awned. Tanniferous cells present and stomatal pores obscured by wax platelets.

CONCLUSIONS

A better understanding of the taxonomy and systematics of *Ehrharta* is needed because its morphological and anatomical variation and its geographic distribution indicate that the genus may provide important clues towards understanding the natural relationships of the Poaceae. The southern African species fall into seven groups based on both spikelet morphology and vegetative anatomy, while the vegetative macromorphology exhibits parallelism and/or convergence between the groups. The series of papers to follow will relate the details of morphological and anatomical structure of each species group to the interpretation of relationships within *Ehrharta*, as it is presently circumscribed and within the rest of the grass family.

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Taxonomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Setacea group

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Keywords: Fynbos, Capensis, *Ehrharta*, Poaceae, taxonomy

ABSTRACT

The Setacea species group in the genus *Ehrharta* Thunb. is differentiated morphologically by the short first sterile lemma and by inflorescences of fewer than 20 spikelets. The Setacea group is composed of two species, each with subspecies linked by intraspecific intermediates: *E. rupestris* Nees ex Trin. subsp. *rupestris*; subsp. *tricostata* (Stapf) Gibbs Russell; subsp. *dodii* (Stapf) Gibbs Russell and *E. setacea* Nees subsp. *setacea*; subsp. *scabra* (Stapf) Gibbs Russell; subsp. *uniflora* (Burch. ex Stapf) Gibbs Russell; subsp. *disticha* Gibbs Russell. All taxa are endemic to the Fynbos vegetation of the south-western Cape Province, with distribution centred in the Caledon degree grid (3419). Parallel trends for plant size and habit, leaf blade width and position, and spikelet size are demonstrated in both species, with similar plant types occurring in similar geographical areas.

UITTREKSEL

Die Setacea-spesiegroep in die genus *Ehrharta* Thunb. word morfologies onderskei deur die kort eerste steriele lemma en deur bloeiwyses van minder as 20 blompakkies. Die Setacea-groep bestaan uit twee spesies, elk met subspesies wat deur intraspesifieke oorgangsvorme by mekaar aansluit: *E. rupestris* Nees ex Trin. subsp. *rupestris*; subsp. *tricostata* (Stapf) Gibbs Russell; subsp. *dodii* (Stapf) Gibbs Russell en *E. setacea* Nees subsp. *setacea*; subsp. *scabra* (Stapf) Gibbs Russell; subsp. *uniflora* (Burch. ex Stapf) Gibbs Russell; subsp. *disticha* Gibbs Russell. Alle taksons is endemies in die Fynbos-plantegroei van die suidwestelike Kaap-provinsie, met die verspreiding in die Caledon-gradievierkant (3419) gesentreer. Paralelle neigings in plantgrootte en -groeiwyse, breedte en posisie van die blaarskyf, en grootte van die blompakkies word in albei spesies aangetoon, met soortgelyke planttipes wat in soortgelyke geografiese gebiede voorkom.

INTRODUCTION

The genus *Ehrharta* in Africa comprises 35 species and infraspecific taxa, and has been divided into seven species groups by correlating many characters of spikelet morphology and leaf blade anatomy, as outlined by Gibbs Russell & Ellis (1987). The leaf blade anatomy in *Ehrharta* shows a wide range of variation. Characters that normally separate groups at subfamily level elsewhere in Poaceae are here used to distinguish species groups. A detailed treatment of variation within each species and species group is therefore called for. Ellis (1987) demonstrates the variation and discusses the significance of leaf anatomy in the Setacea species group. This paper presents the taxonomy of the species in the Setacea group, and places the morphology of the taxa in context with the anatomy, and with the geographical distribution. The other species groups will be similarly treated in parallel papers in the future.

The seven species groups in *Ehrharta* may be classified into two major categories, those with the first and second sterile lemmas similar to each other and different from the fertile lemma (28 species and infraspecific taxa, in six species groups), and those with the first sterile lemma reduced and glume-like, and the fertile lemma similar to the second sterile lemma (seven species and infraspecific taxa in one species group, the Setacea group, Figure 1). In addition, only in the Setacea group is the number of spikelets always fewer than 20 per inflorescence. Ellis (1987) has distinguished the Setacea group anatomically by the presence of arm cells in the

mesophyll (a character normally of significance at subfamily level in grass classification), the shape of the microhairs, the silica bodies and the intercostal long cells. Detailed morphological and anatomical descriptions of the Setacea group are given by Gibbs Russell & Ellis (1987).

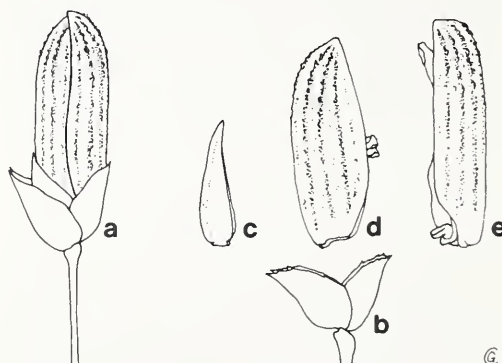


FIGURE 1.—Spikelet of *E. rupestris* subsp. *tricostata*: a, whole spikelet; b, glumes; c, first sterile lemma; d, fertile lemma; e, second sterile lemma (*Esterhuysen* 26708) (×6).

Within what is now regarded as the Setacea group, Nees (1841) recognized two species, and the fundamental difference of their spikelet plan from that of the rest of the genus was demonstrated by Steudel (1853). Stapf (1900) added three new species and a variety, but Gibbs Russell (1984) placed all of Stapf's taxa, plus an additional one, as subspecies within Nees's original two species. These decisions, based on macromorphology and spikelet morphology, are generally supported by

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anatomical studies (Ellis 1987). In most cases, anatomical characters have allowed better interpretation of confusing morphological states; in other cases, morphological and anatomical evidence do not agree. Some of the variation in the Setacea group, where morphological and anatomical characters are contradictory, may be a result of convergent adaptations for tough, long-lived leaves often encountered in plants of the low-nutrient Fynbos soils.

In Africa, *Ehrharta* is a genus characteristic of the winter rainfall areas, and has its centre of diversity in Fynbos, but a number of species also occur in Succulent Karoo, Karoo, Savanna and Forest. Six of the species groups have taxa in more than one vegetation type. The Setacea group is unique in being restricted to Fynbos, and occurs only from the Cape Peninsula north to Worcester and east to Humansdorp.

KEY TO SPECIES IN THE SETACEA GROUP

- Glumes about $\frac{1}{2}$ as long as spikelet 1. *E. rupestris*
 Glumes more than $\frac{1}{2}$ (very rarely only $\frac{1}{2}$) as long as spikelet 2. *E. setacea*

1. *Ehrharta rupestris* Nees ex Trin. in Mémoires de l'Académie impériale des Sciences de St-Petersbourg, sér. 6,5: 25 (1839); Nees: 227 (1841); Stapf: 668 (1900); Chippind.: 37 (1955). Type: Cape Province, Caledon Distr., Gnadenthal, *Drège* (K, isosyn.!, SAM, isosyn.!, PRE, photo.!, fragment!).

Trochera rupestris (Nees) Kuntze: 795 (1891).

Erect or trailing tufted perennial with long creeping rhizomes, of widely varying size and habit, from delicate herbaceous plants 100 mm tall to robust suffrutescent plants 450 mm tall. *Culms* erect or decumbent, branched and creeping at base, leafless below. *Leaves* with blades erect or spreading, inrolled, folded or flat; ligule a membrane fringed with hairs; sheaths overlapping. *Inflorescence* an erect raceme overtopping leaves. *Spikelets* 1–9, erect, often distichous. *Glumes* about $\frac{1}{2}$ length of entire spikelet, lower ones with tip truncate or rounded, upper ones acute. *Florets* with sterile lemmas dissimilar, the first sterile lemma a thin scale with 3–5 raised nerves, $\frac{1}{2}$ – $\frac{1}{2}$ the length of second, often appearing to be a third glume; the second sterile lemma hard and thickened, with 7 minutely tubercled nerves, tip canoe-shaped; fertile lemma similar to second sterile lemma, but slightly shorter, broader and with more acute tip. *Stamens* 6.

(a) subsp. *rupestris*. Gibbs Russell: 150 (1984).

Plants erect, robust, mat- or cushion-forming, to 300 mm tall, with strong woody rhizomes. *Culms* suffrutescent, stiffly erect above. *Leaves* conspicuously distichous, with blades folded, usually held outward at about 45°, or sometimes erect, 20–30 × 2–4 mm, tips hooded; sheaths strongly overlapping, basal sheaths bladeless. *Inflorescence* of 4–8 spikelets, 15–35 mm long, overtopping leaves by at least 3 times its own length. *Spikelets* 4,5–6 mm long, to 2,5 mm across above glumes, oblong to almost square in outline.

The folded leaf blades with hooded tips and the very broad spikelets separate this subspecies from all other taxa in the Setacea group. In spite of these morphological differences, anatomical characters support the combination of subsp. *rupestris* and subsp. *tricostata* under the same species (Ellis 1987).

The distribution of subsp. *rupestris* is shown in Figure 2. It is never common. It is most abundant and appears in its typical form in the Riviersonderend Mountains of the Caledon area. From there it extends northward and eastward, over the Langeberg at the Clock Peaks, and out along the dry Klein and Groot Swartberg, where the plants are smaller. In both the Caledon area and in the Klein Swartberg, where subsp. *rupestris* is sympatric with subsp. *tricostata*, intermediates in leaf and spikelet characters occur between the two subspecies.

The subspecies grows on mountain slopes among rocks at altitudes of 910 to 1 970 m. Flowering occurs from October to January.

A particularly robust specimen otherwise typical of the subspecies (*Van Breda 4436*) was collected on coastal sand in the Vanrhynsdorp region, well outside the usual distribution of the subspecies, and in a different habitat. Nevertheless, the anatomical characters closely resemble those of other examples of subsp. *rupestris* (Ellis 1987). There is some doubt about the correctness of the label of this specimen and its locality has not been plotted on Figure 2. A parallel example is known from *E. calycina*, in a different species group, where an extremely robust plant over 2 m tall was collected on coastal sand near Lambert's Bay (*Gibbs Russell 5615*).

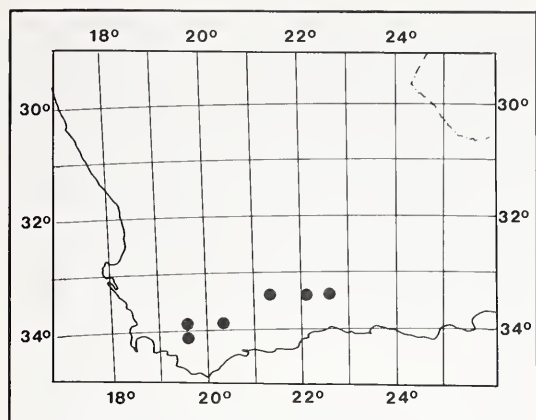
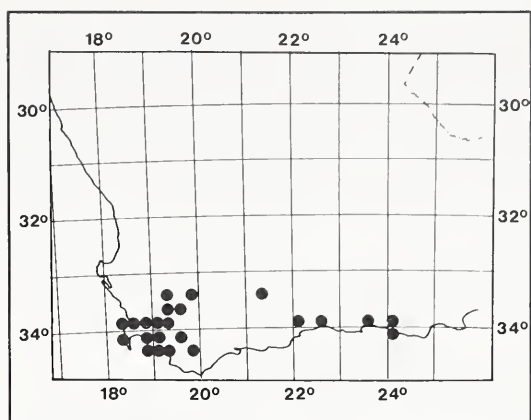
Vouchers: *Boucher 4201* (PRE, STE); *Esterhuysen 21044* (BOL, PRE); *Pocock 572* (PRE); *Thomson 2255* (PRE); *Van Breda 4436* (PRE).

(b) subsp. *tricostata* (Stapf) Gibbs Russell in *Bothalia*: 150 (1984).

Ehrharta tricostata Stapf: 669 (1900); Chippind.: 35 (1955). Type: Cape Province, French Hoek, 2 400 feet, *Schlechter 9292* (K, holo.!, PRE, iso.!).

KEY TO SUBSPECIES

- 1a Plants delicate, herbaceous, less than 250 mm tall; inflorescence of 1–4 spikelets, barely overtopping leaves; spikelets 4,5–5 mm long 1c. *E. rupestris* subsp. *dodii*
 1b Plants ± robust, herbaceous to suffrutescent, 200–450 mm tall; inflorescences of 4–9 spikelets, considerably overtopping leaves; spikelets 4,5–6,3 mm long:
 2a Leaf blades inrolled and appearing setaceous, erect, not distichous, or sometimes flat and ± spreading, tips not hooded; spikelets (above glumes) to 2 mm across, linear to oblong 1b. *E. rupestris* subsp. *tricostata*
 2b Leaf blades folded, somewhat thickened, distichous, usually at 45° to culm, tips hooded; spikelets (above glumes) to 2,5 mm across, oblong to nearly square 1a. *E. rupestris* subsp. *rupestris*

FIGURE 2.—Distribution of *E. rupestris* subsp. *rupestris*.FIGURE 3.—Distribution of *E. rupestris* subsp. *tricostrata*.

Plants erect, tufted, rarely trailing, 200–450 mm tall, with creeping rhizomes. Culms suffrutescent (rarely herbaceous). Leaves with baldes usually inrolled and appearing setaceous, often reduced, erect, or sometimes flat and spreading, not distichous, to 100×2.5 mm, tips tapering, acute; sheaths not strongly overlapping, basal leaves with blades. Inflorescence of 4–9 spikelets, 18–40 mm long, usually considerably overtopping leaves. Spikelets 4.6–6.3 mm long, to 2 mm across above glumes, oblong to linear.

In its size, erect habit, and relative abundance, this subspecies is similar to *E. setacea* subsp. *setacea* but it may be distinguished by the leaves at the base of the culm. *E. rupestris* subsp. *tricostrata* has blade-bearing leaves nearly to the culm base, whereas *E. setacea* subsp. *setacea* has scale-like, overlapping, bladeless sheaths on the lower part of the culms.

The distribution of subsp. *tricostrata* is shown in Figure 3. It is the most common and the most widespread of all seven taxa in the *Setacea* group, extending from the mountains of the Peninsula north to the Hex River Mountains, and eastward to the Klein Swartberg and along the Outeniqua and Tsitsikama coastal ranges nearly to Humansdorp. The subspecies is not recorded from the Langeberg. Plants from the Peninsula and Caledon are the most robust and erect, with reduced setaceous leaf blades; plants from the easternmost end of the range are small and fine, although with suffrutescent culm bases; plants from the Hex River Mountains merge into subsp. *dodii* and are decumbent, herbaceous and have flat leaf blades. All these forms grade gradually into each other. In addition, intermediates link this subspecies with the other two, which might be considered extreme forms. It is clear on anatomical grounds (Ellis 1987) that the smaller form of subsp. *tricostrata* from the eastern part of the range is distinct from the small subsp. *dodii*, even though they overlap in size.

The subspecies grows in wet places on mountain slopes and at the base of cliffs, at altitudes of 300–2 030 m. Flowering extends from October to February, with most plants flowering in November and December.

Vouchers: Ellis 2547 (PRE); Esterhuysen 28594 (BOL, PRE, STE); 32813 (BOL, PRE, STE); 33057 (BOL, PRE, STE); Fourcade 3132 (BOL, PRE, STE).

(c) subsp. *dodii* (Stapf) Gibbs Russell in Bothalia: 150 (1984).

Ehrharta dodii Stapf: 670 (1900); Chippind.: 35 (1955). Type: Cape Province, rocks on Constantia Berg, Wolley Dod 1961 (K, holo.!; BOL, iso.!; PRE, photo.!; fragment!).

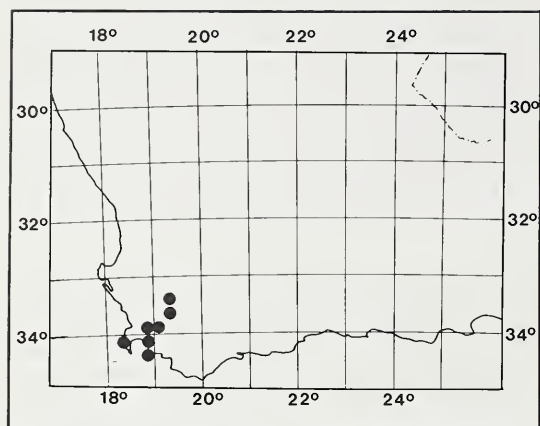
Differs from subsp. *tricostrata* mainly in size, habit and in number of spikelets. Plants are less than 250 mm tall, trailing or rarely erect, and rhizomes, culms, and leaves are herbaceous and delicate, with the culms freely branched and the leaf blades inrolled and held erect. Inflorescence of 1–4 spikelets, 5–10 mm long, barely overtopping leaves. Spikelets 4.5–5 mm long, to 2 mm across above glumes.

This subspecies is difficult to distinguish except on glume length from the two small, delicate subspecies of *E. setacea*. In general, *E. rupestris* subsp. *dodii* is trailing or erect, with erect rolled leaf blades, whereas *E. setacea* subsp. *uniflora* is also trailing, but usually has flat leaf blades, and *E. setacea* subsp. *disticha* is erect with spreading, rolled or folded leaf blades. However, in each taxon the habit is variable to some extent.

The distribution of subsp. *dodii* is shown in Figure 4. It has the most restricted range of any subspecies of *E. rupestris*, occurring only from Constantia Berg on the Peninsula around to Kogelberg, and northward through Hottentots Holland and Franschhoek to the Hex River Mountains. It is connected in the eastern part of its range to subsp. *tricostrata* by intermediates of slightly larger stature, upright habit and with more numerous spikelets. These occur within the range of typical subsp. *dodii* as well as to the east as far as Montagu. The lax Hex River Mountain form of subsp. *tricostrata* should perhaps be counted among these intermediates.

The subspecies grows in wet places on mountainsides among rocks and at the bases of cliffs, at altitudes of 660–1 660 m. Flowering occurs from November to early January.

Vouchers: Boucher 2039 (PRE, STE); Ellis 2286 (PRE); Esterhuysen 33065 (BOL, PRE); 33084 (BOL, JF, PRE); 34169 (BOL, PRE).

FIGURE 4.—Distribution of *E. rupestris* subsp. *dodii*.

2. *Ehrharta setacea* Nees, *Florae Africae Australioris*: 228 (1841). Stapf: 668 (1900); Chippind.: 37 (1955). Type: Cape Province, in monte tabulari, alt. 3 000 ft, *Drège* (PRE, isosyn., fragment!).

Erect or trailing tufted perennials with long creeping rhizomes, sometimes stoloniferous, of widely varying size and habit, from delicate herbaceous plants 100 mm tall to robust suffrutescent plants 600 mm tall. *Culms* decumbent or prostrate, suffrutescent or herbaceous, often leafless below. *Leaves* with blades erect, recurved or spreading, inrolled, folded or flat; ligule a membrane fringed with hairs; sheaths overlapping. *Inflorescence* an erect raceme barely to considerably overtopping leaves. *Spikelets* 1–15, at first erect but spreading at anthesis. *Glumes* $\frac{2}{3}$ (very rarely only $\frac{1}{2}$) as long as to longer than lemmas, both acute. *Florets* as in *E. rupestris*.

(a) subsp. *setacea*. Gibbs Russell: 150 (1984).

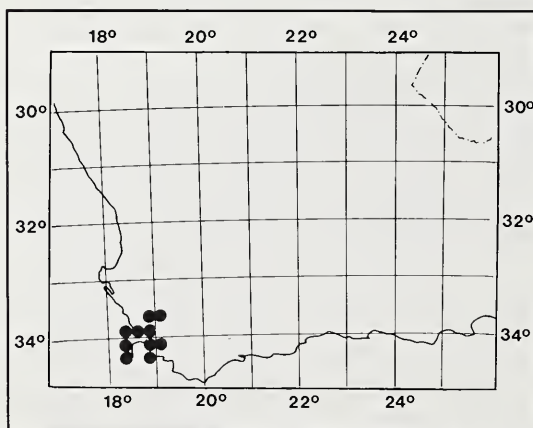
Plant erect, 250–400 mm tall. *Culms* suffrutescent, branched near base, bare of leaves below, sometimes with much shortened inflated side branches. *Leaves* with blades hard, smooth, usually tightly inrolled and appearing setaceous, straight and erect or curved outward and spreading from the middle, 50–80 (110) $\times$ 4 mm; sheaths overlapping at upper internodes, basal sheaths without leaves, yellowish, truncate, slightly spreading. *Inflorescence* of 5–15 spikelets, 25–60 mm long, usually overtopping leaves by at least its own length. *Spikelets* 5.5–6.8 mm long, oblong; glumes $\frac{2}{3}$ as long as, to longer than spikelet, not gaping at maturity.

This subspecies is most similar in habit and size to *E. rupestris* subsp. *tricostata*, but that taxon has blade-bearing sheaths at the lowest culm nodes, while *E. setacea* subsp. *setacea* has conspicuous pale, bladeless, square-topped sheaths at the lower nodes of the culm. Leaf anatomical features (Ellis 1987) suggest that the two taxa might be united. However, each is linked by intermediates to different but parallel lines of morphological variation. The anatomical similarity, which extends even to species in unrelated genera, is an example of convergence in leaf characters common in Fynbos. It is noteworthy that the two taxa with this typical 'Fynbos anatomy' are the most widespread subspecies in the *Setacea* group.

The distribution of subsp. *setacea* is shown in Figure 5. It is the western element of *E. setacea*, and is the most widespread of the four subspecies, occurring from the Cape Peninsula north to Baines Kloof and east only as far as the Hottentots Holland and Kogelberg Mountains. In the Klein Rivier Mountains and at Betty's Bay in the Caledon District it is linked to subsp. *uniflora* and subsp. *disticha* by intermediates of smaller size and semi-herbaceous habit.

The subspecies grows on mountainsides in damp, peaty or marshy places and in seepage areas, either in shale or in sand derived from Table Mountain Sandstone, at altitudes of 660–1 515 m. Flowering occurs from September to December and sporadically until April.

Vouchers: *Esterhuysen* 3574 (BOL, NBG, PRE); 26501 (PRE); 28669 (BOL, PRE, STE); 33245 (BOL, PRE); *Wolley Dod* 3334 (BOL, PRE).

FIGURE 5.—Distribution of *E. setacea* subsp. *setacea*.

KEY TO SUBSPECIES

- 1a Plants 250–400 mm tall, erect; inflorescences of 5–17 spikelets; glumes appressed to florets at maturity:
 - 2a Leaf blades smooth, tightly rolled, appearing setaceous, rigid, erect, straight or curved slightly outward from middle; spikelets 5.5–6.8 mm long 2a. *E. setacea* subsp. *setacea*
 - 2b Leaf blades scabrous, flat and broad (to 6 mm across) at base, rolled near tip, bent 45° outward from culm at sheath; spikelets (6.5) 7–8 mm long 2b. *E. setacea* subsp. *scabra*
- 1b Plants shorter than 250 mm, sprawling or erect; inflorescences of 1–4 spikelets; glumes gaping widely (more than 45°) at maturity:
 - 3a Plants trailing or sprawling, culms herbaceous, lowest nodes bearing leaves with blades; spikelets 4.5–6 mm long; glumes usually slightly longer than lemmas 2c. *E. setacea* subsp. *uniflora*
 - 3b Plants erect, cushion-forming, culms suffrutescent at base, lowest nodes usually leafless; spikelets 4–5 mm long; glumes usually slightly shorter than lemmas 2d. *E. setacea* subsp. *disticha*

(b) subsp. *scabra* (Stapf) Gibbs Russell in Bothalia: 151 (1984).

Ehrharta setacea Nees var. *scabra* Stapf: 669 (1900). Type: Cape, in a mountain peak near Swellendam, Swellendam Div., Burchell 7312 (K, holo.; PRE, photo.).

Plant erect, 250–600 mm tall, stoloniferous. Culms suffrutescent, branched near base, sometimes with much shortened side branches. Leaves with blades scabrous, flat at base, rolled near tip, held 45° from culm at sheath, to 30–110 × 6 mm; sheaths overlapping. Inflorescence of 5–17 spikelets, 30–55 mm long, overtopping leaves by at least twice its own length. Spikelets (6,5) 7–8 mm long, oblong; glumes $\frac{2}{3}$ – $\frac{3}{4}$ as long as lemmas, not gaping at maturity.

This subspecies is easily distinguished from all other African *Ehrharta* species by the scabrous leaf blades, with a texture resembling that of a *Melica* or a *Leersia*. Anatomically, subsp. *scabra* and subsp. *setacea* differ considerably (Ellis 1987), raising the question whether they should be treated as separate species. Despite their anatomical differences and the absence of intermediates between the two allopatric entities, they were kept as subspecies because of the confused situation in the Caledon area, where intermediates occur between subsp. *setacea* and subsp. *scabra* to both subsp. *uniflora* and subsp. *disticha*.

The distribution of subsp. *scabra* is shown in Figure 6. It occurs only along the Langeberg from the Clock Peaks above Swellendam to Garcia's Pass, and thus forms the eastern element of *E. setacea*. In the Caledon area, it is linked through a number of intermediates to subsp. *disticha* and subsp. *uniflora*.

The subspecies grows mostly in disturbed places on mountainsides, such as path sides and burned clearings, and also among rocks in seepage areas, at altitudes of 350–1 212 m. Flowering occurs from October to January and sporadically to March.

Vouchers: Crook 2268 (PRE); Du Toit 2040 (PRE, STE); Haynes 868 (JF, PRE, STE); Taylor 4236 (PRE, STE); 7613 (PRE, STE).

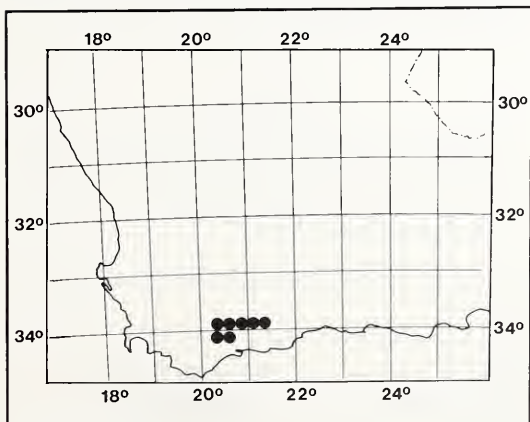


FIGURE 6.—Distribution of *E. setacea* subsp. *scabra*.

(c) subsp. *uniflora* (Burch. ex Stapf) Gibbs Russell in Bothalia: 151 (1984).

Ehrharta uniflora Burch. ex Stapf: 670 (1900); Chippind.: 37 (1955). Type: Cape, Cape Flats near Rondebosch, Burchell 182 (K, holo.; PRE, fragment!).

Plants sprawling or trailing, delicate but forming dense masses. Culms fine, herbaceous, freely branched, lowest nodes bearing leaves with blades. Leaves not distichous, blades soft, flat, straight, 50–80 × 2 mm; sheaths barely or not overlapping. Inflorescence of 1–4 spikelets, 5–14 mm long, barely overtopping leaves. Spikelets 4.5–6.5 mm long; glumes usually slightly longer than lemmas but sometimes slightly shorter, gaping more than 45° at maturity.

This subspecies can be distinguished from the other two small taxa in the *Setacea* group by its long glumes (*E. rupestris* subsp. *dodii* has short glumes) or trailing habit (*E. setacea* subsp. *disticha* is erect).

The distribution of subsp. *uniflora* is shown in Figure 7. It is known only around False Bay, from the Cape Peninsula to Pringle Bay. In the Caledon District intermediates occur to subsp. *setacea* and subsp. *scabra*.

The subspecies grows in seepage areas, marshy places and along watercourses, as well as at forest margins. It is the only taxon in the *Setacea* group to occur at low altitudes, from 10–500 m. Flowering occurs from September to December, and occasionally to March.

Vouchers: Adamson 1331 (BOL, PRE); Cleghorn 3168 (PRE, STE); Esterhuysen 34002 (BOL, PRE); 34039 (BOL, NBG, PRE).

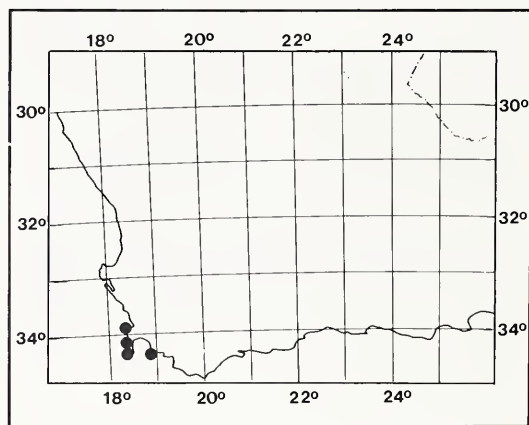


FIGURE 7.—Distribution of *E. setacea* subsp. *uniflora*.

(d) subsp. *disticha* Gibbs Russell in Bothalia: 151 (1984). Type: Cape, Caledon District, Maanschynkop, Rocklands Park, Esterhuysen 31735 (PRE, holo.; BOL, iso.).

Plant erect, cushion-forming, to 250 mm tall, differing from subsp. *scabra* mainly in size, number of spikelets and position of glumes. Culms branched near base, suffrutescent, lowest nodes usually leafless. Leaves distichous, blades hard, rolled, recurved or erect, to 30 mm long. Inflorescences of 1 or 2 spikelets, 5–10 mm long, barely overtopping leaves. Spikelets 4–5 mm long; glumes slightly shorter than lemmas, gaping more than 45° at maturity.

This small subspecies is separated from short-glumed *E. rupestris* subsp. *dodii* by its long glumes, and from lax *E. setacea* subsp. *uniflora* by its erect habit and generally smaller spikelets with glumes slightly shorter than the spikelet.

The distribution of subsp. *disticha* is shown in Figure 8. It is known only from the Babylon's Tower and Klein River Mountains of the Caledon area. A number of intermediate specimens show that in this area it intergrades with subsp. *setacea* and subsp. *scabra*.

The subspecies grows in dry rocky places on mountain slopes, at altitudes of 580–1 225 m. All other taxa in the Setacea group grow in damp or wet places. The striking habit difference between subsp. *disticha* and subsp. *uniflora* may result from adaptation of the former to water stress in a dry habitat. Flowering occurs in October and November.

Vouchers: *Esterhuysen 31735* (BOL, PRE); *32319* (BOL, PRE); *33647* (BOL, PRE); *34755* (BOL, PRE); *Williams 3086* (NBG, PRE).

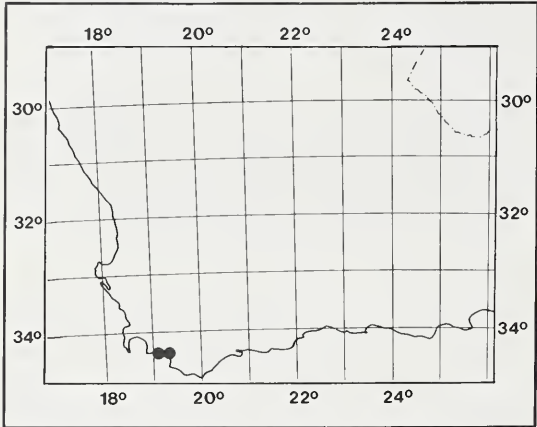


FIGURE 8.—Distribution of *E. setacea* subsp. *disticha*.

CONCLUSION

The Setacea group is composed of very closely related taxa, as shown by both morphological and anatomical characters. These taxa are distinguished from other *Ehrharta* species by the spikelet plan, with a short first sterile lemma, and by a number of anatomical features. These distinctive characteristics indicate that the Setacea group must be carefully reviewed when generic limits in the Ehrharteae are examined. The Setacea group has a more restricted distribution than any other group in the genus. All the subspecies except *E. setacea* subsp. *scabra* occur in the Caledon degree grid (3419), and examples of all the intermediates also occur in this degree grid. Thus, the Setacea group is concentrated in the south-western phytogeographical centre of Weimarck (1941) and the smaller south-western centre of Oliver *et al.* (1983). Outside this pivotal area, each taxon has a

distinctive distribution. Only one subspecies occurs throughout the range of the group, *E. rupestris* subsp. *tricostata*. The other subspecies show vicariant distribution, limited to particular mountain ranges.

Although they are very similar, the seven infraspecific taxa recognized here are each distinguished by macro-morphological, spikelet and anatomical differences. The occurrence of intermediates links them into two groups with parallel morphological trends, as shown in Table 1. These two groups are treated as separate species, with the linked entities which they comprise treated as subspecies. In each species, the most widespread and commonly collected subspecies is a robust plant with hard setaceous leaves: *E. rupestris* subsp. *tricostata* and *E. setacea* subsp. *setacea*. Each species has a robust subspecies of more restricted eastern distribution differentiated from the widespread one by broader spreading leaf blades and larger spikelets: *E. rupestris* subsp. *rupestris* and *E. setacea* subsp. *scabra*. Each species has little delicate subspecies with reduced inflorescences and small spikelets in the Peninsula and Caledon area: *E. rupestris* subsp. *dodii*, *E. setacea* subsp. *uniflora* and *E. setacea* subsp. *disticha*. Each of these reduced taxa has a distinctive habitat. *E. rupestris* subsp. *dodii* grows in wet places at high altitudes, *E. setacea* subsp. *uniflora* grows in wet places at low altitudes, and *E. setacea* subsp. *disticha* grows in dry places at high altitudes. Thus, the factors in the Caledon area that favour small size are apparently independent of moisture regime and altitude.

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TABLE 1.—Parallel trends in subspecies for the two species of the Setacea group. Arrows indicate the existence of specimens intermediate between subspecies

Adaptation and distribution	Plant large, robust; leaves setaceous, erect; widespread distribution	Plant small; leaves delicate; 'False Bay' distribution	Plant large, robust; leaves broad, spreading; 'Eastern' distribution
<i>E. rupestris</i>	subsp. <i>tricostata</i>	subsp. <i>dodii</i>	subsp. <i>rupestris</i>
<i>E. setacea</i>	subsp. <i>setacea</i>	subsp. <i>uniflora</i> subsp. <i>disticha</i>	subsp. <i>scabra</i>

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- SPECIMENS EXAMINED
- Adamson 596 (2a) BOL; 616 (2a) PRE; 660 (2a) BOL; 1331 (2c) PRE, BOL. *Andreae* 1283 (1b) PRE.
- Bews 15169 (2a) BOL. *Bolus* 7978 (1b/2a) BOL; 33866 (2a) PRE. *Bond* 668 (1b) NBG. *Boucher* 2039 (1c) K, PRE, STE; 2069 (1b) PRE, STE; 2642 (2a) STE; 2645 (1c) K, STE; 4201 (1a) PRE, STE. *Burchell* 182 (2c) K, PRE; 7312 (2b) K, PRE; 7419 (1a) K.
- Cleghorn 3168 (2c) PRE, STE; 3174 (2a/2c) K, PRE, STE. *Compton* 15486 (2a) NBG; 17505 (2a) NBG. *Crook* 2268 (2b) K, PRE.
- Drège 1659 (2a) PRE; 1661 (1a) K, PRE; 19358 (1a) SAM. *Du Toit* 2040 (2b) PRE, STE.
- Ellis 1678 (2b) PRE; 1679 (2b) PRE; 2273 (2a) PRE; 2286 (1c) PRE; 2287 (1c) PRE; 2294 (2a) PRE; 2544 (2b) PRE; 2547 (1b) PRE; 4652 (2b) PRE; 4653 (2b) PRE; 4669 (2b/2c) PRE; 4670 (2b/2c) PRE; 4679 (2a) PRE; 4685 (1a) PRE; 4689 (2b) PRE; 4690 (1b) PRE; 4700 (1b) PRE. *Esterhuysen* 1541 (1b) BOL; 3574 (2a) BOL, NBG, PRE; 6770 (1b) BOL, NBG, PRE, SAM; 9498 (2a) BOL; 10876 (1b) BOL; 10974 (1c) BOL; 21044 (1a) BOL, PRE; 22354 (2a) BOL, PRE; 22676 (1c) BOL, PRE; 24081 BOL, PRE; 26501 (2a) PRE; 26708 (1a/1b) BOL, PRE; 27368 (1b) BOL, PRE; 27558 (2b/2c) BOL, K, PRE; 28067 (2a) BOL, PRE; 28109 (1b) BOL, K, NBG, PRE; 28267 (1b) PRE; 28594 (1b) BOL, K, PRE, STE; 28619 (1b/1c) BOL, K, PRE; 28651a (1c) BOL, K; 28669 (2a) BOL, K, PRE, STE; 28683 (2b/2c) BOL, K; 28712 (1b) BOL, K, PRE, STE; 28777 (2b) BOL, K, PRE; 29936 (2b/2c) BOL, K, PRE, STE; 30045a (2c) BOL; 31424 (2b/2c) BOL, K; 31735 (2d) BOL, PRE; 32319 (2d) BOL, K, PRE; 32553 (2a) BOL; 32727 (1c) BOL, K, PRE; 32792 (1b) BOL, K, PRE; 32813 (1b) BOL, K, PRE, STE; 33040 (2c) BOL, PRE; 33047 (1b) BOL, K, PRE; 33056 (2c) BOL, PRE, STE; 33057 (1b) BOL, K, PRE, STE; 33065 (1c) BOL, K, PRE; 33084 (1c) BOL, JF, K, PRE; 33150 (1b) BOL; 33245 (2a) BOL, PRE; 33299 (1b/1c) BOL; 33511 (1c) BOL, PRE; 33520 (1b) BOL, K; 33523 (1b) BOL, PRE; 33647 (2d) BOL, K, PRE; 33662 (2a/2c) BOL, PRE; 33724 (2c) BOL, PRE; 33733 (1c) BOL, K; 33762 (1b) BOL, K; 34002 (2c) BOL, PRE; 34039 (2c) BOL, NBG, PRE; 34122 (1b) BOL, K, PRE; 34168 (1b/1c) BOL, PRE; 34169 (1c) BOL, K, PRE; 34173 (1b) BOL, K, PRE; 34183 (1b) BOL, K; 34497 (1c) BOL, K; 34505 (1b) K, PRE; 34557 (1b) BOL, K; 34755 (2d) BOL, K, PRE; 34778 (2a) BOL; 34834 (1b) BOL, PRE; 35300 (1b) BOL, K, PRE; 35364 (1a) BOL, K; 35539a (2d) BOL, K; 35571 (1b) BOL; 35620 (1b) BOL; 35621 (1a) BOL; 35733 (1b) BOL; 35812 (1c) BOL; 35822 (2a) BOL; 35835 (1b) BOL.
- Forsyth 355 (2a) JF. *Fourcade* 3132 (1b) BOL, K, PRE, STE.
- Galpin 164 (2a/2c) PRE, STE. *Gibbs Russell* 5634 (2b) BOL, K, NBG, PRE; 5635 (2b) BOL, K, PRE; 5652 (2b/2c) BOL, K, NBG, PRE; 5671 (2a) BOL, K, NBG, PRE; 5671a (1c) PRE; 5675 (1c) PRE; 5676 (1a) BOL, K, NBG, PRE; 5678 (1a) PRE; 5682 (2b) BOL, K, NBG, PRE; 5696 (1b) BOL, K, NBG, PRE.
- Haynes 868 (2b) JF, PRE, STE.
- Kerfoot 5709 (1b) JF. *Kruger* 276 (1b) JF; 521 (2a) JF, PRE; 651 (1c) JF; 1099 (1b) JF, STE; 1515 (1b) JF, STE; 1599 (1c) JF.
- Pappe 53 (2a) PRE. *Pocock* 572 (1a) PRE.
- Schlechter 1825 (2b) BOL, K; 9292 (1b) BOL, K, PRE; 9869 (1a/1b) BOL, K, PRE. *Stokoe* 2537 (1b/1c) PRE; 7810 (2a) BOL; 8640 (1a) BOL; 22547 (1b) BOL; 67667 (2a) SAM; 67675 (1a) SAM.
- Taylor 3222 (2b) PRE, STE; 4236 (2b) PRE, STE; 7613 (2b) K, PRE, STE; 7668 (2c) PRE. *Thompson* 1597 (1b) PRE, STE; 2255 (1a) PRE. *Thorne* 43440 (2b) SAM; 44556 (1a) SAM; 45847 (1a) SAM. *Van Breda* 4436 (1a) PRE. *Van der Merwe* 25–52 (2a) PRE; 933 (2a) PRE, STE; 934 (2a) PRE, STE. *Van Rensburg* 215 (2a) PRE.
- Williams 2887 (2d) NBG; 2963 (1b) K, NBG, PRE; 3015 (1b) K, NBG, PRE; 3086 (2d) K, NBG, PRE; 3150 (2b/2d) K. *Wolley Dod* 1961 (1c) BOL, K, PRE; 3334 (2a) BOL, K, PRE.
- Zeyher 19359 (2a) SAM.

Leaf anatomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Setacea group

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Keywords: arm cells, Capensis floral kingdom, *Ehrharta*, *E. rupestris*, *E. setacea*, leaf anatomy, Poaceae, southern Africa, systematics

ABSTRACT

The leaf blade anatomy of the taxa of the Setacea group of species of the genus *Ehrharta* is described and illustrated. This group includes *E. rupestris* Nees ex Trin. subsp. *rupestris*, subsp. *tricostata* (Stapf) Gibbs Russell and subsp. *dodii* (Stapf) Gibbs Russell, as well as *E. setacea* Nees subsp. *setacea*, subsp. *scabra* (Stapf) Gibbs Russell, subsp. *uniflora* (Burch. ex Stapf) Gibbs Russell and subsp. *disticha* Gibbs Russell. All these taxa share a very characteristic leaf anatomy with inrolled or infolded leaves without keels and have adaxial ribs with interlocking prickles. The chlorenchyma is dense and compact with inwardly projecting invaginations visible in all taxa except *E. setacea* subsp. *setacea*. In *E. setacea* subsp. *scabra* typical arm cells are present. Abaxial costal and intercostal zones are not differentiated and stomata are absent. The long cells are hexagonal or inflated with sinuous walls. Silica bodies are single or paired and rounded in shape. Small hook-like prickles with short barbs are common. Microhairs with a short, truncated distal cell occur. This leaf anatomical structure differs considerably from that of the other species groups recognized in African *Ehrharta* and the Setacea group appears to be more distinct from the other groups than they are from each other.

UITTREKSEL

Die blaarskyfanatomie van die taksons van die Setacea-spesiegroep van die genus *Ehrharta* word beskryf en geïllustreer. Hierdie groep sluit *E. rupestris* Nees ex Trin. subsp. *rupestris*, subsp. *tricostata* (Stapf) Gibbs Russell en subsp. *dodii* (Stapf) Gibbs Russell asook *E. setacea* Nees subsp. *setacea*, subsp. *scabra* (Stapf) Gibbs Russell, subsp. *uniflora* (Burch. ex Stapf) Gibbs Russell en subsp. *disticha* Gibbs Russell in. Al hierdie taksons het 'n baie kenmerkende blaaranatomie gemeen. Die blare is ingerol of ingevou, sonder 'n kiel en het adaksiale ribbe met ineensluitende doringe. Die chlorenchiem is dig en kompak met instulpings van die selwande sigbaar in alle taksons behalwe *E. setacea* subsp. *setacea*. In *E. setacea* subsp. *scabra* is tipiese vertakte selle teenwoordig. Die abaksiale kostale en interkostale sones is nie onderskeibaar nie en huidmondjies is afwesig. Die langselle is seshoekig of opgeblaas en met gekartelde wande. Silikaliggaampies is enkel of gepaard en het 'n ronde vorm terwyl die stekelhare met kort weerhake toegerus is. Mikrohare met 'n kort afgeknotte distale sel kom voor. Hierdie anatomiese struktuur verskil aansienlik van dié van al die ander spesiegroepe in *Ehrharta* in Afrika en die Setacea-groep blyk 'n afsonderlike groep te wees wat meer van die ander groepe verskil as wat hulle van mekaar verskil.

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INTRODUCTION

The African species of *Ehrharta* fall into two natural groups: those with the first sterile lemma similar to the second, and the fertile lemma differing from both; and those with the first sterile lemma reduced and scale-like,

and the fertile lemma similar to the second sterile lemma (Gibbs Russell 1984). About 20 species belong to the first group, but the second group, to which the Setacea group belongs, contains only two species: *E. rupestris* Nees ex Trin. and *E. setacea* Nees, together with seven subspecific taxa. These two species, therefore, differ considerably in spikelet structure from the other species groups in the genus and, morphologically, the Setacea group appears to be rather isolated from the rest of the genus. This paper will examine whether the leaf anatomy of the representatives of this group confirms this observation, and will discuss the affinities of this group by reference to the anatomical evidence.

Chippindall (1955) recognized five species with a short sterile lemma but Gibbs Russell (1984, 1987) has combined these into only two species, each with several subspecies. Within each species there are parallel trends for reduced size and spikelet number, for rolled, folded or flat, erect or spreading leaf blades and for suffrutescence. This apparently reticulate pattern of relationships, which generally applies to the genus *Ehrharta*, results in parallel or convergent trends in vegetative parts occurring in different taxa recognized on the basis of spikelet differences. It is of interest to determine whether the leaf anatomical variation parallels that exhibited by the spikelets and whether it substantiates the morphological classification based on relative glume length. This paper will copiously illustrate, describe briefly and evaluate the leaf anatomy of each of the seven subspecies of the two species of this group with reference to the systematic position of these taxa and of the group as a whole relative to the genus and the higher classification of the Poaceae.

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E. rupestris* Nees ex Trin. subsp. *rupestris

Transverse section

The median vascular bundle is indistinguishable structurally from the lateral first order bundles (Figure 1.1), as is the case throughout this group. Smaller third order bundles occur on either side of the median bundle and near the margin (Figure 1.1; 1.3) and, perhaps, second order bundles should be distinguished in this taxon. However, if these irregular and ill-defined additional bundles are excluded then only two smaller bundles separate consecutive first order bundles, as is the case in all other taxa in this group. The presence of these additional bundles is not considered to be taxonomically significant and probably only represents individual variation in the specimen studied.

Rounded adaxial ribs and narrow furrows are present (Figure 1.2; 1.3), the furrows having interlocking adaxial prickles (Figure 2.1). Similar prickles also occur on subsp. *tricostata* but are absent on subsp. *dodii*.

The chlorenchyma tissue is compact, consisting of small round cells with dense chloroplasts (Figure 1.2). These cells do not have straight, isodiametric sides but do have slight, but clearly discernible wall invaginations (Figure 1.2; 1.3). According to the generally accepted definition of arm cells, these must be considered as such and, in fact, they do closely resemble the arm cells of the *Oryzae* and some of the other bambusoid grasses. These invaginations are better developed in subsp. *rupestris* than in either subsp. *tricostata* or subsp. *dodii* and a definite reduction series is evident in these three subspecies.

Abaxial epidermis

The epidermis conforms very closely to the type diagnostic for this group, with the costal and intercostal zones being structurally undifferentiated and with the long cells being very short and inflated to hexagonal with sinuous walls (Figure 1.4; 1.5). Abaxial stomata were not detected with the light microscope, neither in

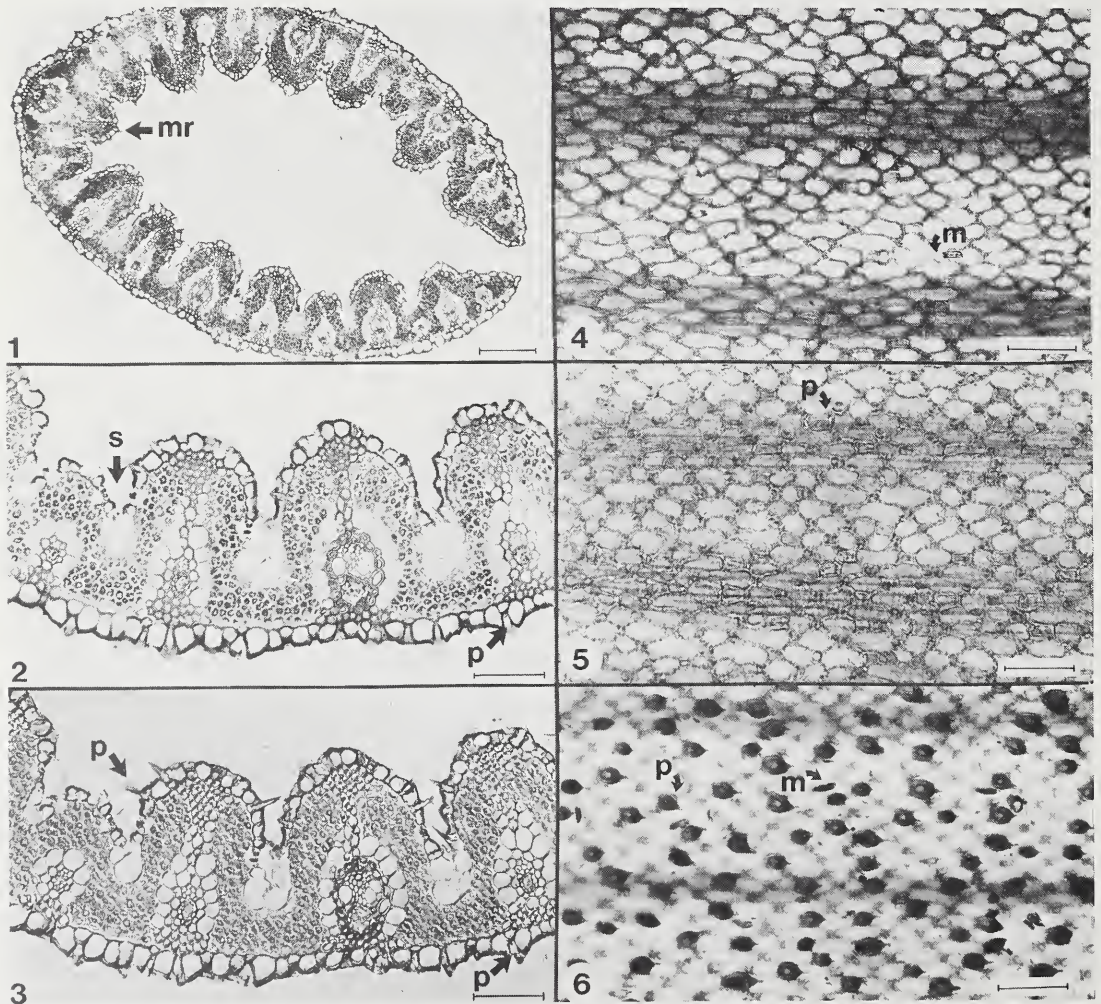


FIGURE 1.—Leaf anatomy of *Ehrharta rupestris* subsp. *rupestris*. 1–5, *Ellis 4685*. 1–3, leaf transverse sections; 1, infolded leaf blade with median vascular bundle (mr) only, scale = 20 μm . 2, compact mesophyll with chlorenchyma cells with slight wall invaginations, adaxial stomata (s) only and abaxial hooks (p) with short barbs, scale = 10 μm . 3, interference contrast showing long barbs of adaxial prickles (p) and short barbs of abaxial hooks (p), scale = 10 μm . 4–5, abaxial epidermis: 4, costal and intercostal zones of similar cells, note microhair (m), scale = 10 μm ; 5, costal and intercostal long cells separated by hooks, prickles (p) or silica bodies, scale = 10 μm . 6, abaxial epidermis of *Van Breda 4436* showing costal and intercostal hooks (p) and microhairs (m), scale = 10 μm .

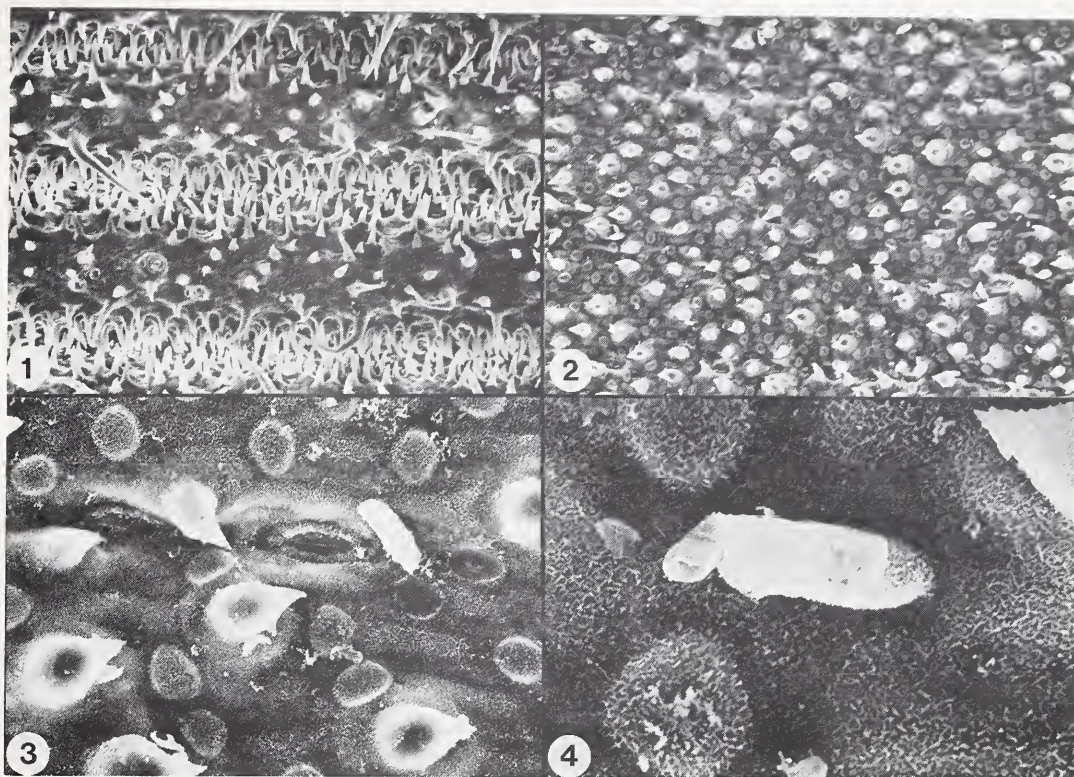


FIGURE 2.—Epidermal ultrastructure of *Ehrharta rupestris* subsp. *rupestris*. 1–4, Ellis 4685. 1, adaxial epidermis showing ribs and furrows with interlocking prickles, $\times 60$; 2–4, abaxial epidermis: 2, epidermal zonation not evident and prickles are widespread, $\times 60$; 3, detail of prickles, stomata and papilla-like silica bodies, $\times 340$; 4, microhair and silica bodies, $\times 1000$.

transverse sections (Figure 1.2; 1.3) nor in epidermal preparations (Figure 1.4–1.6). However, the SEM revealed a few isolated stomata deeply sunken between the inflated long cells and obscured by hooks (Figure 2.3).

Silica bodies are structurally identical throughout the epidermis and appear as single, rounded bodies located between the long cells (Figures 1.4; 1.5). Under the SEM these are clearly seen to be raised, rounded structures covered with epicuticular wax (Figure 2.3; 2.4). As such they are indistinguishable from papillae and do not resemble the usual silica bodies with their concave faces devoid of wax platelets. Their refractive nature is visible with the light microscope (Figure 1.5) and they can also be seen to be raised (Figure 1.6). They are undoubtedly silica bodies but they are highly unusual and their exact nature and structure remains somewhat uncertain. Comparable structures have not been described elsewhere in the literature and they deserve further study. Similar structures also occur in *E. setacea* and they appear to be a unique characteristic of this group of *Ehrharta* species.

The entire abaxial epidermis is densely covered in shortly barbed hooks occupying the same locations between the long cells as the silica bodies (Figure 1.6). These hooks can occupy up to 50% of the available localities (Figure 1.6) but may be fewer in number (Figure 1.4; 1.5). The hooks with their reduced barbs may be difficult to distinguish from the silica bodies with the light microscope but are definitely distinct structures as seen under the SEM (Figure 2.2; 2.3).

The microhairs of subsp. *rupestris* are also of interest in that they are very short, with a blunt distal cell which does not taper to a point (Figure 2.3; 2.4). They are common throughout the epidermis (Figure 1.4; 1.6) and are an important distinguishing feature between this group and all the other groups of *Ehrharta*.

Specimens examined

CAPE.—3118 (Van Rhynsdorp): Vredendal Distr., Koekenap (–CB), Van Breda 4436. 3319 (Worcester): Riviersonderend Mts, Jonas Kop (–DC), Ellis 4685.

Discussion

A small and inadequate sample was studied anatomically and, consequently, little information on variation in this subspecies can be deduced. However, the specimen from the Van Rhynsdorp District in Succulent Karoo comes from an atypical habitat and is particularly robust (Gibbs Russell 1984) and yet closely resembles the specimen from the Mountain Fynbos in leaf anatomy. It, therefore appears as if the leaf anatomy of this taxon is stable and consistent despite differing environmental conditions.

E. rupestris subsp. *rupestris* is obviously very closely related to subsp. *tricostata* and the two can hardly be separated anatomically and, with a larger study sample, can be expected to grade into one another. The cross-sectional anatomy tends to support the diagnostic difference of folded (Figure 1.1) versus rolled (Figure 3.1; 3.4) leaf blades (Gibbs Russell 1984, 1987) even though subsp. *tricostata* is not rolled in the same way as subsp.

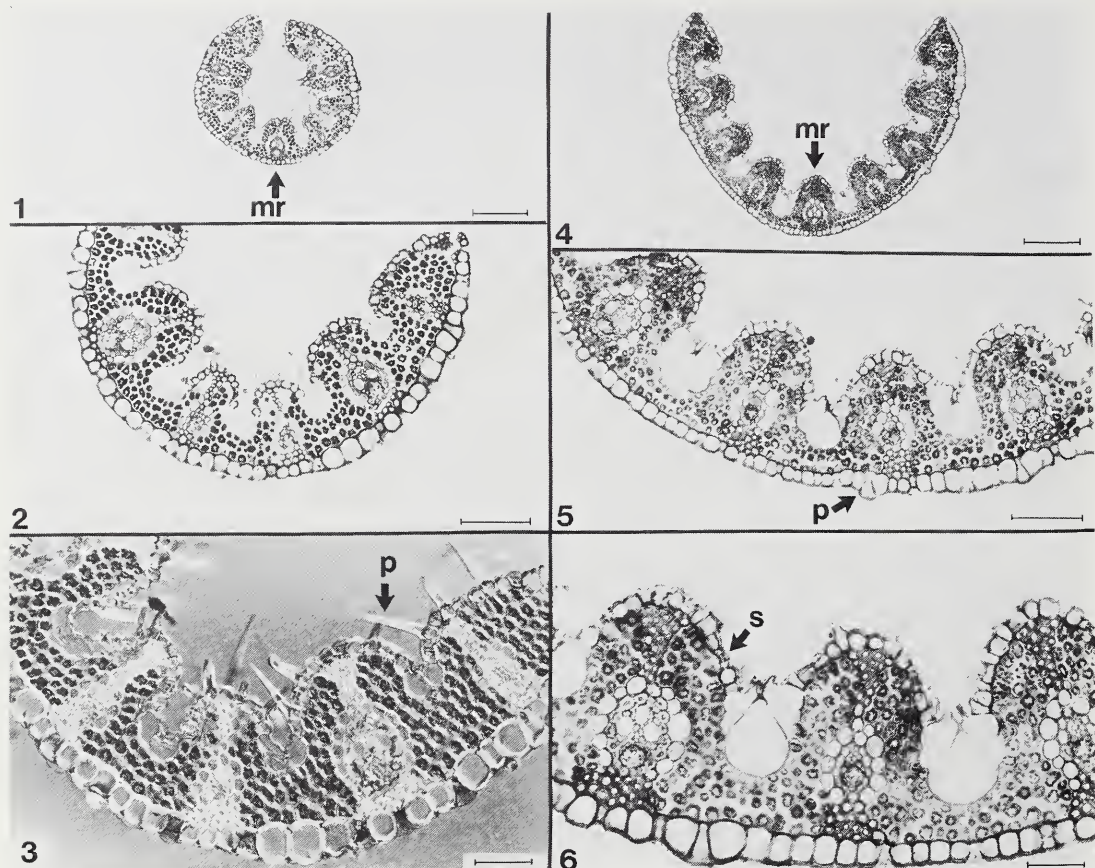


FIGURE 3.—Transsectional leaf anatomy of *Ehrharta rupestris* subsp. *tricornata*. 1–3, Ellis 4700: 1, inrolled leaf outline with median vascular bundle (mr), scale = 20 μ m; 2, compact mesophyll with cells densely packed with chloroplasts, scale = 10 μ m; 3, interference contrast showing very slight inward projections of walls of chlorenchyma cells and long barbs of adaxial prickles (p), scale = 5 μ m. 4–6, Ellis 4690: 4, infolded leaf outline, scale = 20 μ m; 5, arrangement of first and third order vascular bundles, scale = 10 μ m; 6, detail of chlorenchyma with some cells showing slight indentations and adaxially located stomata (s) only, scale = 5 μ m.

dodii (Figure 6.1; 6.3). This morphological difference is, therefore, not very convincing when it is analysed structurally. Further anatomical studies are required to confirm whether these two taxa are anatomically distinct; all indications are that only infraspecific separation is justified. This study, therefore, supports the decision of Gibbs Russell (1984, 1987) to reclassify *E. tricornata* as a subspecies of *E. rupestris*. It must also be noted that these two subspecies show greater similarities with each other than either does to subsp. *dodii*.

***E. rupestris* Nees ex Trin. subsp. *tricornata* (Stapf) Gibbs Russell**

Transverse section

No keels or midribs are present (Figure 3.1; 3.4) and successive first order vascular bundles are separated by two third order bundles (Figure 3.2; 3.5). The outline of the lamina is very similar to that of subsp. *rupestris* and these two taxa differ only in subsp. *rupestris* having considerably wider leaf blades which are infolded but with the arms of the lamina curved outwards. In subsp. *tricornata* the leaf blades are narrower and setaceous with no angle being present at the median bundle (Figure 3.1; 3.4) and these leaves can be considered as being inrolled

although the margins do not overlap as in subsp. *dodii*. This distinction between subsp. *tricornata* and subsp. *rupestris* is only minor and intermediates can be expected when a larger sample is studied. Both these subspecies also possess a ribbed adaxial surface with interlocking prickles overlying the furrows (Figure 3.3).

The mesophyll is compact, of small regular cells. The cells are rounded and very tightly packed (Figure 3.3) and closer inspection reveals very slight inward projections on only a few cell walls (Figure 3.3; 3.6). These cells resemble arm cells but cannot be considered to be typical and may result from reduction of the type of invagination described in subsp. *rupestris*.

Abaxial epidermis

The epidermal structure is virtually identical to that of subsp. *rupestris* as illustrated in Figure 4.1–4.4. The prickles are not always very common and may lack barbs (Figure 4.4) but the solitary, round silica bodies are clearly visible (Figure 4.2). Ultrastructurally these bodies are also seen to be raised and papilla-like (Figure 5.3) and not concave as typical silica bodies usually are. The microhairs have a short, blunt distal cell (Figure 5.4)

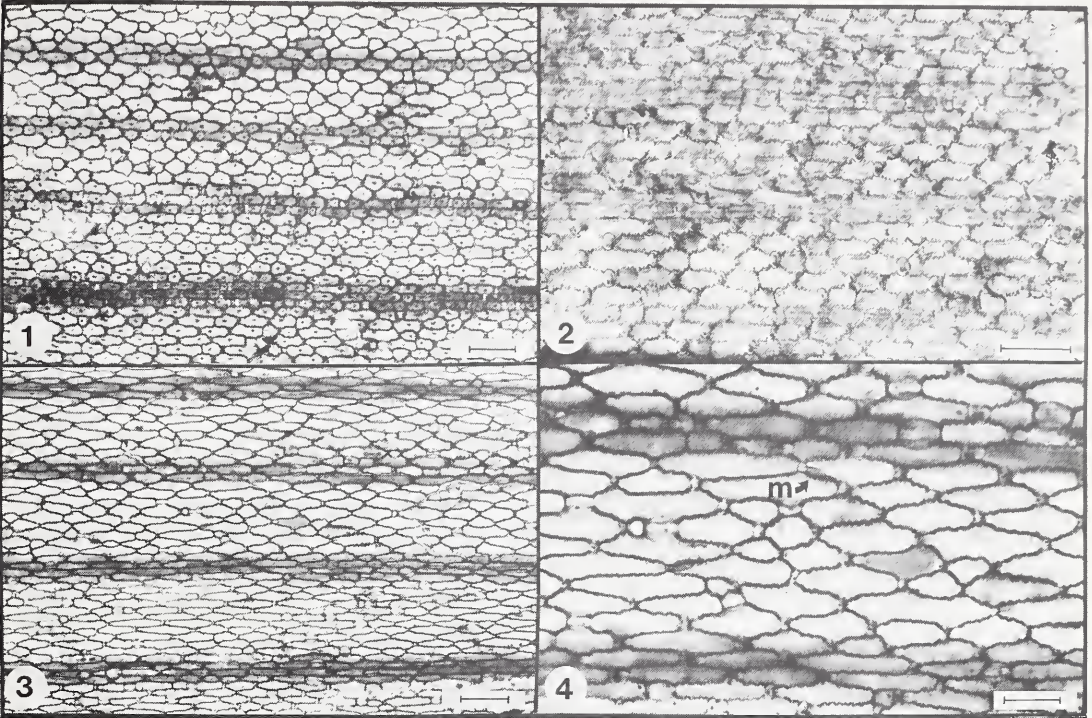


FIGURE 4.—Abaxial epidermis of *Ehrharta rupestris* subsp. *tricostata*. 1–2, *Ellis 4700*: 1, costal and intercostal files of similar composition, scale = 10 μ m; 2, interference contrast showing silica cells or hooks between all long cells, scale = 10 μ m. 3–4, *Ellis 4690*: costal and intercostal long cells diamond shaped, scale = 10 μ m; 4, intercostal long cells with thickened, pitted walls, note microhair (m), scale = 10 μ m.

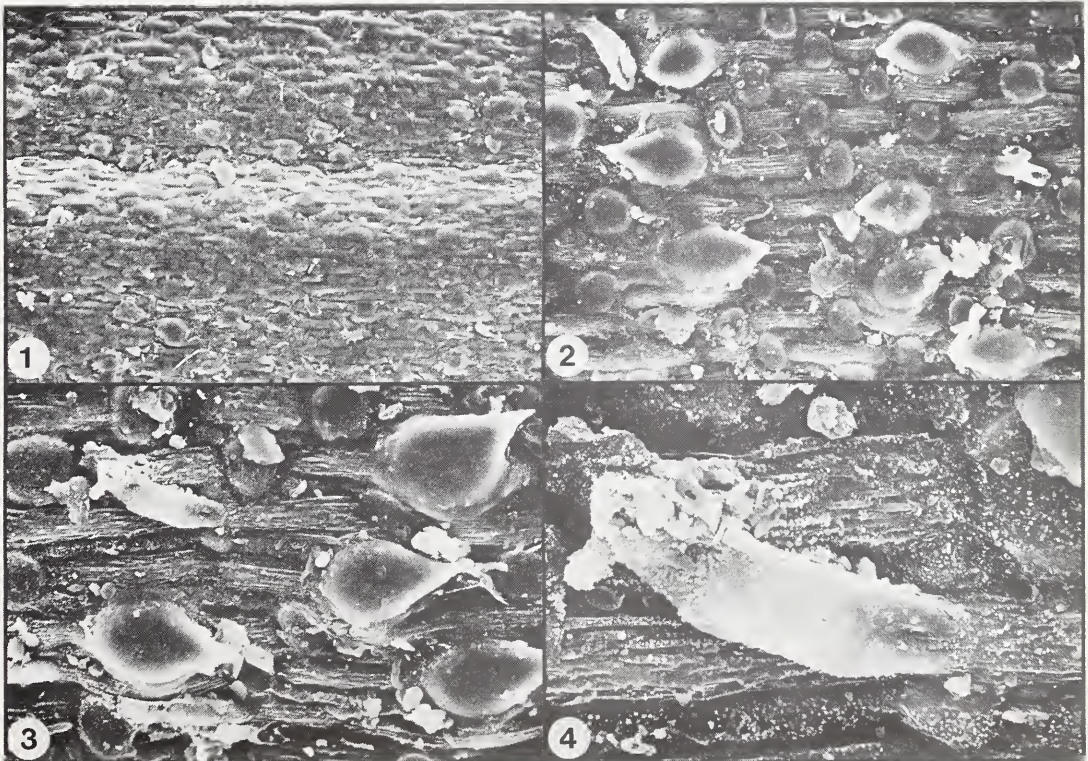


FIGURE 5.—Abaxial epidermis of *Ehrharta rupestris* subsp. *tricostata*. 1, *Ellis 4690* showing absence of costal and intercostal zonation, $\times 60$. 2–4, *Ellis 4700*: 2, prickles common and short long cells separated by raised silica bodies, $\times 200$; 3, prickles with short barbs, microhairs and long cells, $\times 300$; 4, detail of microhair and cuticular striations on long cells, $\times 1000$.

and are unusual in this regard in the genus. The epicuticular wax layer in subsp. *tricostata* is very thick with distinct horizontal striations (Figure 5.3; 5.4) and not of fine platelets as in subsp. *rupestris* (Figure 2.3; 2.4).

Specimens examined

CAPE.—3321 (Ladismith): Riversdale Distr., Langeberg, Garcia's Pass (—CC), *Ellis* 4690. 3322 (Oudtshoorn): Outeniqua Mts, Robinson's Pass (—CC), *Ellis* 2547, 4700.

Discussion

Anatomically subsp. *tricostata* is very similar indeed to subsp. *rupestris* and these two taxa cannot be satisfactorily distinguished on anatomical criteria. This is supportive of their separation at only the subspecies level (Gibbs Russell 1984) and the leaf anatomy confirms the extremely close relationship of these two taxa. The recognition of two separate species is not corroborated by the anatomical evidence.

E. rupestris Nees ex Trin. subsp. *dodii* (Stapf) Gibbs Russell

Transverse section

No keel is present (Figure 6.1; 6.3) and the adaxial ribs and furrows are not well developed and interlocking prickles are absent (Figure 6.2). Of particular interest is the convolute inrolling of the leaf blade (Figure 6.1; 6.3). This type of inrolling does not occur in either subsp. *rupestris* or subsp. *tricostata* and appears to be a significant anatomical difference between these two subspecies and subsp. *dodii*.

The mesophyll tissue is compact, of small rounded and regular cells (Figure 6.2). These cells cannot be regarded as being typical arm cells as they possess only very slight invaginations.

Abaxial epidermis

The costal and intercostal zones are structurally undifferentiated although their relative positions can be determined due to the staining of the sclerenchyma girders underlying the costal zones (Figure 6.4). The long cells are considerably longer and less inflated than in either of the other two subspecies of *E. rupestris*. All three subspecies do have sinuous long cell walls and stomata are either very rare (subsp. *rupestris*) or absent from the abaxial surface. The silica bodies are also rounded but they are closely associated with a cork cell. Although these structures were not examined ultrastructurally, there can be little doubt that they are typical graminoid silica bodies and not the unusual type described in subsp. *tricostata* and subsp. *rupestris*. Prickles with prominent oval bases and very short barbs are common (Figure 6.4). Small microhairs, typical of those of the Setacea group, are also present (Figure 6.4).

Specimens examined

CAPE.—3418 (Simonstown): Hottentot Hollands Mts, Sir Lowry's Pass (—BB), *Ellis* 2286, 2287; Kogelberg State Forest, Platberg (—BD), *Boucher* 2039.

Discussion

In its leaf anatomy *E. rupestris* subsp. *dodii* differs more from subsp. *rupestris* and subsp. *tricostata* than

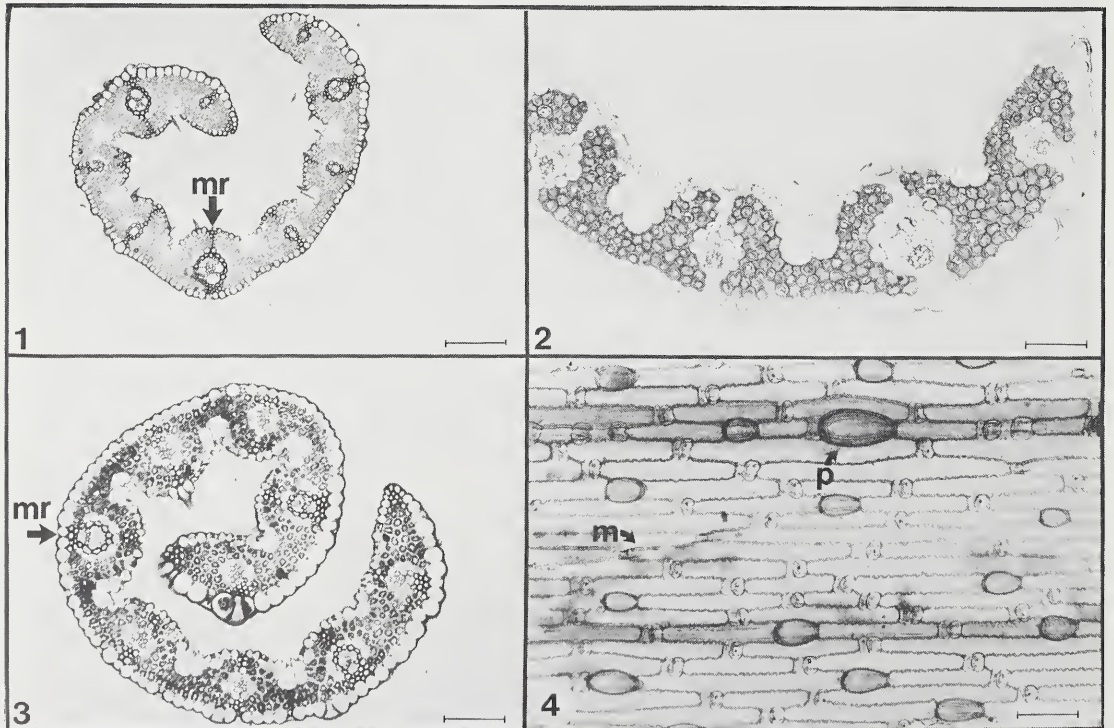


FIGURE 6.—Leaf anatomy of *Ehrharta rupestris* subsp. *dodii*. 1–3, leaf in transverse section. 1–2, *Ellis* 2286: 1, inrolled outline with simple median vascular bundle (mr), scale = 10 μ m; 2, compact mesophyll of rounded cells with slight wall indentations, scale = 5 μ m. 3, *Ellis* 2287, showing inrolled outline, few adaxial prickles and simple median bundle (mr), scale = 10 μ m. 4, abaxial epidermis, *Ellis* 2287, note absence of stomata, microhairs (m), costal prickles (p) and intercostal hooks, scale = 5 μ m.

these two subspecies differ from one another. The findings of this study, based on only a very small sample, appear to indicate that subsp. *dodii* is sufficiently distinct from *E. rupestris* to warrant separate specific status. Additional anatomical material may reveal anatomical intermediates with subsp. *tricostata* but this appears rather unlikely in view of the entirely different nature of the involution of the blades of these two taxa. The convolute type of inrolling in subsp. *dodii* may indicate a different type of bud veneration to that of subsp. *tricostata* where inrolling is of the involute type. If this proves to be true then the case for separation at the species level will be strengthened.

Although subsp. *dodii* differs somewhat from subsp. *rupestris* and subsp. *tricostata* in leaf anatomy, their anatomy is still typical of the Setacea group and different from that of all the others of *Ehrharta* (Gibbs Russell & Ellis 1987). Subsp. *dodii*, therefore, unquestionably belongs to this very distinct group.

The less acicular type of leaf transection and the elongation of the epidermal long cells seems to be paralleled in *E. setacea* in subsp. *disticha* and subsp. *uniflora*. This trend may be related to the milder climate of the Cape Peninsula and Caledon District to which these three taxa are restricted. These three subspecies do not occur at higher altitudes in the mountain ranges further inland as do *E. rupestris* subsp. *rupestris* and subsp. *tricostata* and *E. setacea* subsp. *setacea* and subsp. *scabra*. This trend, associated with a more mesophytic type of anatomy and elongated epidermal cells with costal and intercostal zones and with abaxial stomata, may represent the convergent trends so evident in this group. Alternatively this pattern may reflect the reticulate nature of relationships which also characterizes this group. It is therefore an academic decision whether subsp. *dodii* should be recognized as a separate species or not. Whatever basis is used to define species in this group, other characters will not necessarily follow the same pattern. The decision is also dependant on a similar decision being made for subsp. *disticha* and subsp. *uniflora* in *E. setacea*.

E. setacea Nees subsp. *setacea*

Transverse section

This taxon has the leaf outline which typifies this group: the blades are setaceous, without midribs or keels (Figure 7.1; 7.3) and with well developed adaxial ribs and furrows (Figure 7.2; 7.4). Subsp. *setacea* is notable in having acicular leaf blades of the permanently in-folded type with the abaxial epidermal cells being very large and regular in size as seen in transection (Figure 7.2; 7.4).

The chlorenchyma is exceptionally compact and consists of straight-walled, isodiametric cells (Figure 7.2; 7.4). The chloroplasts are dense, peripherally arranged and with a central vacuole. No invaginations are visible. This chlorenchyma is identical in appearance to the type so common in the Danthonieae in genera such as *Merxmüllera*, particularly *M. disticha* (Schrad.) Nees (Ellis 1980), *Pseudopentameris* (Ellis 1985a) and some species of *Pentameris* (Ellis 1985b,c).

Abaxial epidermis

Costal and intercostal zones are not differentiated (Figure 7.5; 7.7), the long cells are short and fusiform

(Figure 7.6; 7.8) and separated by a single, raised silica body (Figure 12.1). Abaxial stomata are absent as are hooks and prickles. Microhairs are infrequent (Figure 7.8) or absent (Figure 7.6) but when present are short with rounded distal cells (Figure 12.2).

Specimens examined

CAPE.—3418 (Simonstown): Hottentots Holland Mts, Sugarloaf Peak (—BB), *Ellis* 2273; Sir Lowry's Pass (—BB), *Ellis* 2294; Landrost-kop, Somerset Sneeuwkop (—BB), *Ellis* 4679.

Discussion

The leaf anatomy conforms closely to that typical of the Setacea group, and subsp. *setacea* resembles *E. rupestris* subsp. *rupestris* and subsp. *tricostata* very closely in leaf anatomy. It differs mainly in the absence of abaxial prickles. Other slight differences, such as the chlorenchyma cell invaginations and the epidermal cells in tranverse section which are regular in size, due to the absence of prickle hair bases, are only differences of degree. Anatomically, therefore, subsp. *setacea* clearly belongs to the Setacea group. Whether it should be separated from *E. rupestris* is debatable according to the anatomical evidence and *E. setacea* subsp. *setacea* has more in common with *E. rupestris* subsp. *tricostata* than it has with any of the other subspecies of *E. setacea*. The leaf anatomy appears to indicate that these two taxa are conspecific and the relative glume length, which is used to separate *E. setacea* from *E. rupestris* (Gibbs Russell 1984), results in an apparently artificial anatomical grouping. This observation is particularly relevant when the anatomy of subsp. *setacea* is compared with that of subsp. *scabra*, as these taxa exhibit significant anatomical differences which would justify at least specific separation in other grass groups.

Once again the classification of taxa within the Setacea group presents problems with contradictory anatomical and morphological evidence. A possible explanation for this situation lies in different rates of evolution in different organs combined with a reticulate evolutionary pattern. Present knowledge indicates that, whatever characters are used to distinguish taxa in this group, heterogeneity of other character sets will result. This makes a generally acceptable classification almost impossible to achieve.

The anatomical resemblance between subsp. *setacea* (and *E. rupestris* subsp. *tricostata* as well) and many of the winter rainfall danthonoid grasses deserves further mention. Both in section and epidermis subsp. *setacea* closely resembles species of *Pseudopentameris* (Ellis 1985a), and *Pentameris* (Ellis 1985b,c) in particular. These similarities may only be coincidental but it is more probable that they result from convergent evolution. Convergent and parallel patterns appear to be common in Cape fynbos grass species. Most species of the mountain regions, where nutrients are severely limiting, have evolved a structurally complex, long-lived leaf, in contrast to the lowland species in which the leaves are deciduous (or the plants annual) with a much simpler internal structure, with thinner cell walls, less sclerenchyma and larger air spaces. This general pattern cuts across phylogenetic lines at the generic level and does not appear to be taxonomically significant. What is of importance, however, is that here taxa from different subfamilies have responded identically to similar environmental conditions.

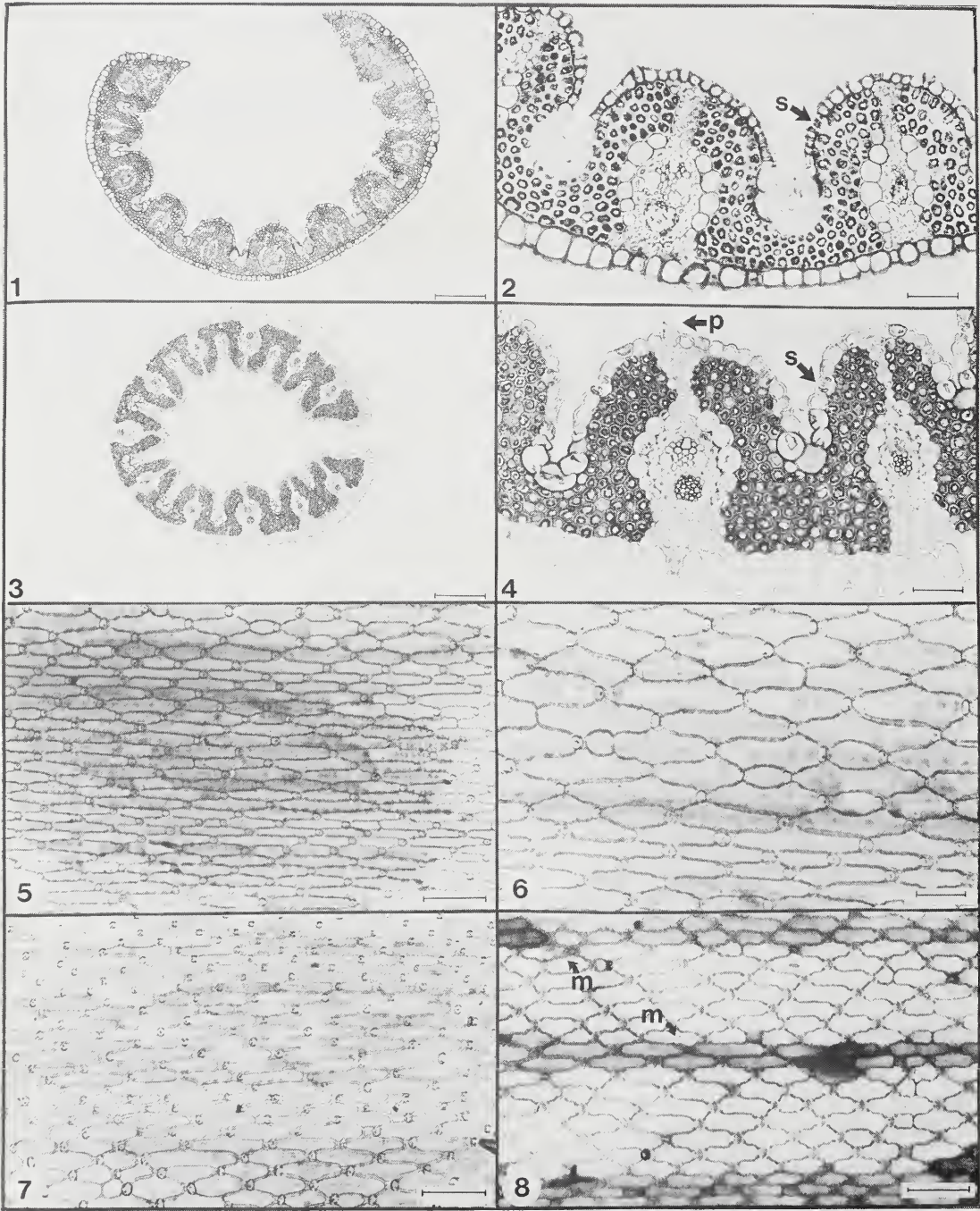


FIGURE 7.—Leaf anatomy of *Ehrharta setacea* subsp. *setacea*. 1–2, *Ellis 4679*: 1, leaf outline showing inrolling and undifferentiated midrib, scale = 20 μ m; 2, anatomical detail with compact chlorenchyma and adaxial stomata (s), scale = 5 μ m. 3–4, *Ellis 2273*: 3, inrolled outline, scale = 20 μ m; 4, isodiametric chlorenchyma cells without wall invaginations, scale = 5 μ m. 5–6, *Ellis 2294*, abaxial epidermis. 5, costal and intercostal zone cell structure similar, scale = 10 μ m; 6, hexagonal long cells separated by cork-silica cell pairs, scale = 5 μ m. 7, *Ellis 2273*, costal and intercostal zones not clearly differentiated, scale = 10 μ m. 8, *Ellis 4679*, note small, indistinct microhairs (m), scale = 10 μ m.

E. setacea* Nees subsp. *scabra* (Stapf) Gibbs Russell*Transverse section**

This subspecies has a wide, expanded type of lamina (Figure 8.1; 8.3) which is not of the setaceous type of subsp. *setacea*. In all specimens, even those in which the blade is almost flat, there are indications of convolute infolding (Figures 8.1; 8.3). This is reminiscent of the condition in *E. rupestris* subsp. *dodii*. Slight adaxial ribs and wide, open furrows (Figures 8.2; 8.4; 8.6) resemble the subsp. *dodii* condition more than subsp. *setacea*.

The single most significant anatomical feature of subsp. *scabra* is the possession of definite arm cells in the mesophyll (Figures 8.2; 8.4; 8.5; 8.6). These are typical arm cells with distinct invaginations of the cell walls visible in all chlorenchyma cells (Figures 8.2; 8.4) and the chloroplast pattern is also indented, indicating the presence of these inward projections of the cell walls (Figures 8.5; 8.6). Typical arm cells are, however, sometimes lacking in subsp. *scabra* (Ellis 4653). Arm cells do not occur in subsp. *setacea* but indications of their existence are evident in all other taxa of the Setacea group.

Abaxial epidermis

The structure of the epidermis is very similar to that of *E. rupestris*. Absence of zonation, short fusiform long cells, no stomata, rounded silica bodies and hook-like prickles (Figure 9.1–9.4) occur in subsp. *scabra* and characterize the taxa of the Setacea group. Ultrastructurally this similarity is confirmed by the raised papilla-like silica bodies (Figure 12.3) and short microhairs with rounded distal cells (Figure 12.4). This epidermal structure differs somewhat from that of subsp. *setacea* and subsp. *uniflora* but is virtually identical to that of *E. rupestris* subsp. *rupestris* and subsp. *tricostata*.

Specimens examined

CAPE.—3320 (Montagu): Barrydale Distr., Tradouw's Pass (–DC), Ellis 1678, 1679, 4652, 4653 (varies anatomically). 3321 (Ladismith): Riversdale Distr., Langeberge, Garcia's Pass (–CC), Ellis 2544, 4689.

Discussion

Arm cells are considered to be a very important character in the systematics of the Poaceae and the presence of these cells in subsp. *scabra* may be taxonomically meaningful. Arm cells are a diagnostic characteristic of

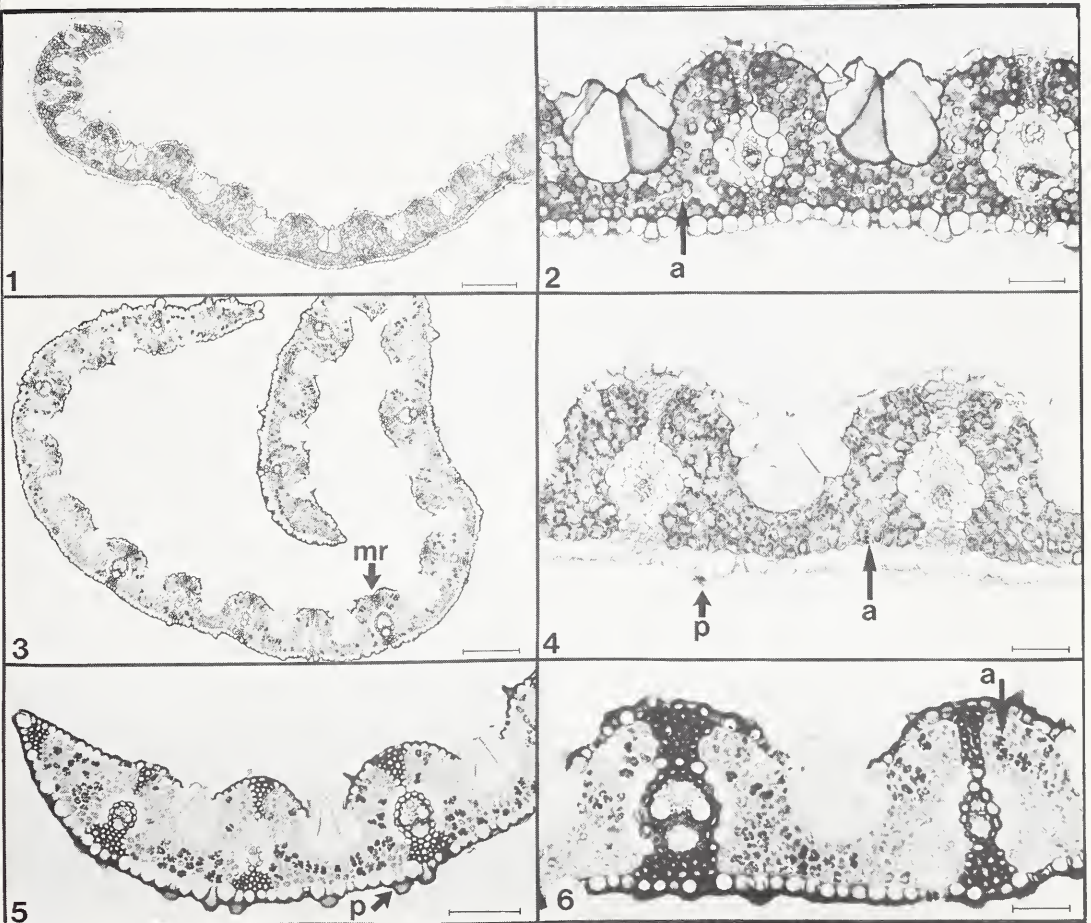


FIGURE 8.—Cross-sectional leaf anatomy of *Ehrharta setacea* subsp. *scabra*. 1–2, Ellis 4689: 1, broad, expanded outline, scale = 20 μ m; 2, anatomical detail clearly showing arm cells (a), scale = 5 μ m. 3–4, Ellis 2544: 3, inrolled but broad leaf with median vascular bundle (mr) only, scale = 20 μ m; 4, arm cells (a) with distinct cell wall invaginations, scale = 5 μ m. 5, Ellis 1679, leaf margin showing arm cells and abaxial prickles (p), scale = 10 μ m. 6, Ellis 1678, arm cells (a) of chlorenchyma densely filled with chloroplasts, scale = 10 μ m.

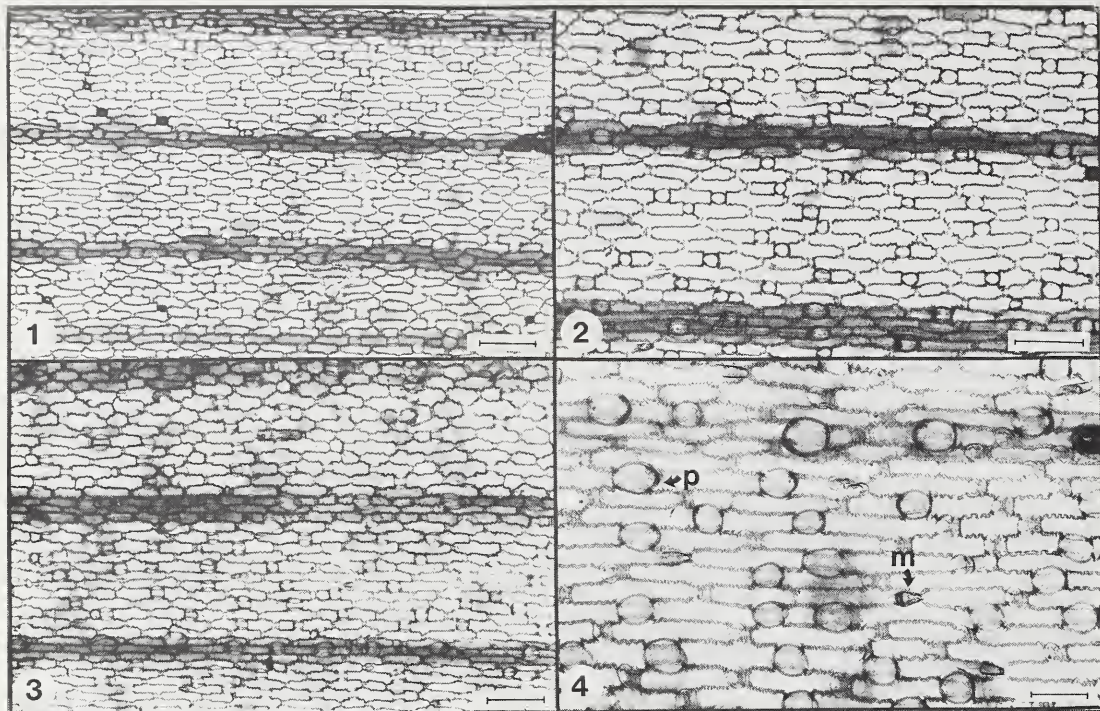


FIGURE 9.—Abaxial epidermal structure of *Ehrharta setacea* subsp. *scabra*. 1–2, *Ellis 4689*: 1, cell arrangement, scale = 10 μm ; 2, costal and intercostal zones only slightly differentiated, scale = 10 μm . 3–4, *Ellis 4652*: 3, cell pattern consistent throughout abaxial epidermis, scale = 10 μm ; 4, microhairs (m) and shortly barbed prickles (p), scale = 5 μm .

the Bambusoideae (including Oryzeae) and, as such, are a feature of high taxonomic value. However, arm cells are known sporadically from non-bambusoid groups. Examples are *Phragmites* and *Thysanolaena* of the Arundinoideae and *Sclerodactylon* and the Triodeae of the Chloridoideae (Watson *et al.* 1985). This occurrence of arm cells in these apparently unrelated groups is impossible to explain but indicates that the presence of arm cells in the Setacea group of *Ehrharta* does not necessarily imply bambusoid relationships for the genus. However, their presence can undoubtedly be used to substantiate the arguments of those workers (Renvoize 1986) in favour of bambusoid affinities for *Ehrharta*. However,

the occurrence of fully developed arm cells in only one taxon of the genus *Ehrharta* urges caution in attaching too much importance to their presence.

A certain degree of anatomical variation was observed in this subspecies. This variation applies particularly to the presence of stomatal bands in the abaxial epidermis (Figure 10.3) with an associated development of clear structural differentiation between the costal and intercostal zones. The specimen displaying this type of structure (*Ellis 4653*) was collected growing together with *Ellis 4652*, which has the anatomy typical of subsp. *scabra*, whereas *Ellis 4653* is a much more robust plant with an

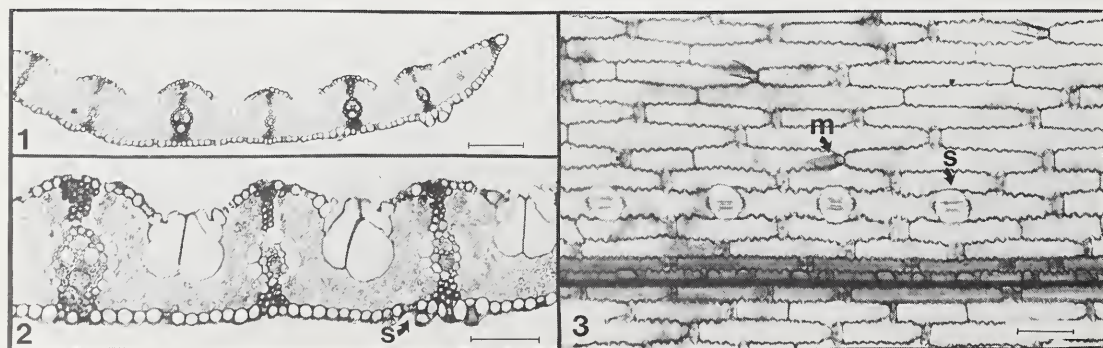


FIGURE 10.—Anatomical variation in *Ehrharta setacea* subsp. *scabra*, *Ellis 4653*. 1–2, leaf sections: 1, margin of open, expanded leaf, scale = 20 μm ; 2, mesophyll not compact and not comprised of distinct arm cells, note abaxial stomata (s), scale = 10 μm . 3, abaxial epidermis showing stomatal bands (s), microhairs (m) and clear cellular differentiation between costal and intercostal zones, scale = 5 μm .

extremely dense underground rhizome system. The anatomy of this specimen is illustrated in Figure 10 and it can be seen to differ from typical subsp. *scabra* in the presence of abaxial stomata, the epidermal zonation and by having elongated intercostal long cells (Figure 10.3) and by the absence of typical arm cells, with the invaginations being poorly developed (Figure 10.2). The microhairs are also more elongated (Figure 12.6) and there are fewer prickles (Figure 12.5). The anatomy of this specimen is, therefore, intermediate between that of subsp. *scabra* and subsp. *uniflora* which has abaxial stomata, no prickles and elongated, tapering microhairs (Figure 12.7; 12.8). A few isolated stomata were also observed on the epidermis of *Ellis 4689*, a rather robust specimen with wide leaves (Figure 8.1). However, in this specimen, the epidermal zones are not structurally differentiated (Figure 9.1; 9.2) and the arm cells are clearly developed (Figure 8.2). It is possible that a whole range of intermediates will be found between *E. setacea* subsp. *scabra* and subsp. *uniflora* and *disticha*. Unfortunately the latter two subspecies are poorly represented in this study and it was not possible to determine the exact pattern of variation between these taxa.

E. setacea Nees subsp. *uniflora* (Burch. ex Stapf)
Gibbs Russell

Transverse section

This subspecies has a narrow but flat and expanded leaf outline (Figure 11.1) with poorly developed ribs and furrows (Figure 11.3). This is not the setaceous type of leaf outline as in subsp. *setacea*, and abaxial stomata are clearly visible even in transection (Figure 11.3; 11.4). There is also no indication of convolute inrolling as in subsp. *scabra*.

The mesophyll of subsp. *uniflora* is also not as compact as in all the other taxa of the *Setacea* group (Figure 11.2; 11.4), a difference which appears to be associated with the development of an air-space system linked to the abaxial stomata. The mesophyll cells themselves cannot be considered to be classical arm cells (Figure 11.2; 11.4) although very slight invaginations are visible in some of the chlorenchyma cell walls.

Abaxial epidermis

The presence of a single file of stomata on either side of each costal zone (Figure 11.5; 11.6) distinguishes the

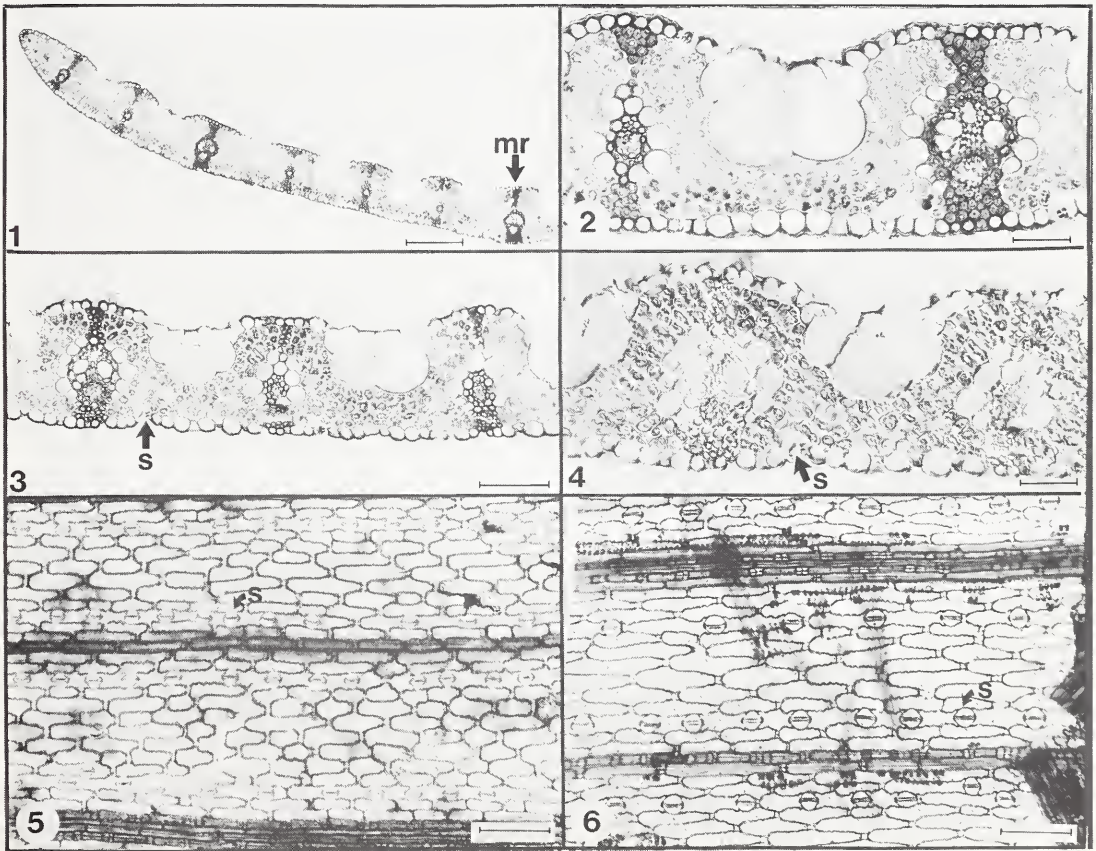


FIGURE 11.—Leaf anatomy of *Ehrharta setacea* subsp. *uniflora*. 1–2, *Ellis 4670*, transections: 1, open, expanded outline with median vascular bundle (mr) only, scale = 20 μ m; 2, anatomical detail showing chlorenchyma which is not composed of typical arm cells, scale = 5 μ m. 3–4, *Ellis 4669*, transections: 3, abaxial stomata (s) common, scale = 10 μ m; 4, interference contrast showing only slight wall indentations and abaxial stomatal aperture (s), scale = 5 μ m. 5, abaxial epidermis, *Ellis 4670*, with single file of stomata (s) on either side of each costal zone, scale = 10 μ m. 6, abaxial epidermis, *Ellis 4669*, showing stomata (s) and clearly differentiated costal zones, scale = 10 μ m.

epidermis of this subspecies from all the other taxa of the Setacea group (except subsp. *disticha*). There is also a definite tendency for the costal zones to be structurally different from the intercostal zones (Figure 11.6) with the silica bodies being different. The intercostal long cells are not separated by raised silica bodies as in the other subspecies of *E. setacea* (Figure 12.1; 12.3; 12.5; 12.7). In this respect subsp. *uniflora* differs from all other members of the Setacea group. Other differences are the tapering microhairs (Figure 12.8) and the presence of epicuticular wax (Figure 12.7).

Specimens examined

CAPE.—3418 (Simonstown): Cape Peninsula, Chapman's Peak (–AB), *Esterhuysen* 34039. 3419 (Caledon): Olifantsberg, Hermanus (–AD), *Ellis* 4669, 4670, *Esterhuysen* 31039.

Discussion

The leaf anatomy of subsp. *uniflora* appears to be intermediate between that of the Setacea group and some of the other groups of the genus *Ehrharta*. This contention is supported by the epidermal zonation with abaxial stomata, the presence of epicuticular wax, the absence of raised silica bodies, the tapering microhairs and the less compact mesophyll tissue. These features are all characteristic of the Setacea group and subsp. *uniflora* differs from the other taxa in this group in all these attributes which tend toward the condition found in several of the other infrageneric groupings in *Ehrharta*.

The leaf anatomy of subsp. *uniflora* is very similar indeed to that of *Ellis* 4653, an atypical subsp. *scabra* specimen (Figure 10). *Ellis* 4653 is a much more robust plant with wider leaf blades than any subsp. *uniflora* specimen. This is not reflected in the leaf anatomy, however, and leaf thickness and epidermal cell size are comparable. Only the width of the lamina is different. It appears that the loss of the setaceous, acicular type of leaf results in a very similar anatomy, irrespective of which subspecies this occurs in. The development of abaxial stomata appears to be the most significant change and it is associated with several other anatomical features such as the zonation of the epidermis and the presence of an extensive air-space system accompanied by less compact mesophyll. The loss of the Setacea type of silica body and the possession of tapering microhairs is not explained by the development of abaxial stomata, however, and they appear to be additional differences not linked to the presence of these stomata.

Subsp. *uniflora* grows at very low altitudes, from 10–500m (Gibbs Russell 1984) and this is a possible reason for the development of these abaxial stomata. Temperatures are less extreme at these lower altitudes with an equable maritime climate and the nutritional status of the soil is considerably better than the leached soils at higher altitudes. More material of subsp. *uniflora* is required to gain a better understanding of the interrelationships of these taxa.

E. setacea Nees subsp. *disticha* Gibbs Russell

Transverse section

No fresh material of this taxon was available for anatomical study and, consequently, the transectional anatomy was not examined.

Abaxial epidermis

The epidermal structure is very similar to that described for subsp. *uniflora*, with stomatal files and

clearly differentiated costal and intercostal zones (Figures 13.1; 13.2). Intercostal hooks are absent and the intercostal silica bodies appear to be of the raised type typical of the Setacea group but they are associated with cork cells (Figure 13.2). Microhairs are common and appear to be longer than the type usually found in this group (Figure 13.2).

Specimens examined

CAPE.—3419 (Caledon): Caledon Distr., Vogelgat (–AD), *Williams* 3086.

Discussion

The epidermal anatomy of subsp. *disticha* is virtually identical to that of subsp. *uniflora* and it is predicted that the leaf anatomy of these two taxa will also be very similar. This supports their classification as subspecies of the same species (Gibbs Russell 1984). Freshly fixed material for anatomical study is required to confirm the prediction.

DISCUSSION

The leaf anatomy of several species of *Ehrharta* has been studied by various authors (Metcalf 1960; Jacques Felix 1962; Renvoize 1985) but none of these studies, except those of Tateoka (1963) dealt with any representatives of the Setacea group. Tateoka (1963) included four species of this group but did not notice any arm cells. Consequently, the unique anatomy of this most interesting group has received very little attention. If the presence of these arm cells had been reported earlier, it is certain that it would have had a profound influence on the classification of the genus in the Poaceae. On the evidence of spikelet morphology and embryo anatomy (Reeder 1957, 1962) *Ehrharta* has been placed in the Oryzae (Stebbins & Crampton 1961). However, the leaf blade anatomy of the representatives studied to date showed no affinity with the Bambusoideae (Tateoka 1963). The genus has therefore been retained in the Arundinoideae, with which it conforms in leaf anatomy (Renvoize 1981). Awareness of the arm cells in the Setacea group would undoubtedly have strengthened the argument for retention of the genus in the Bambusoideae.

For these reasons it is regrettable that the detailed and comprehensive study of the genus by Engelbrecht (1956) was never published. In this thesis, 26 species of *Ehrharta* were studied in detail and their structure interpreted with considerable insight. Unfortunately, this work has remained virtually unknown and has not been considered in the taxonomy of the genus to date.

Engelbrecht (1956) observed wall invaginations in all members of the Setacea group except *E. setacea* subsp. *scabra* and subsp. *disticha* which were not examined by him. In addition, he reported the presence of arm cell-like invaginations in *E. rehmannii*, *E. ramosa*, *E. subspicata*, *E. gigantea* and *E. villosa*. These latter observations are not substantiated by the present study (Gibbs Russell 1987) and will be discussed fully in a later paper. Engelbrecht (1956) used the possession of these arm cells to divide the genus into two distinct groups of species. The group with arm cells was further subdivided into those without dumbbell-shaped silica bodies (the Setacea group) and those with dumbbell-shaped silica bodies (the Villosa and Ramosa groups). His circumscription of the Setacea group is, therefore, identical to the conclusions of the present study and it is

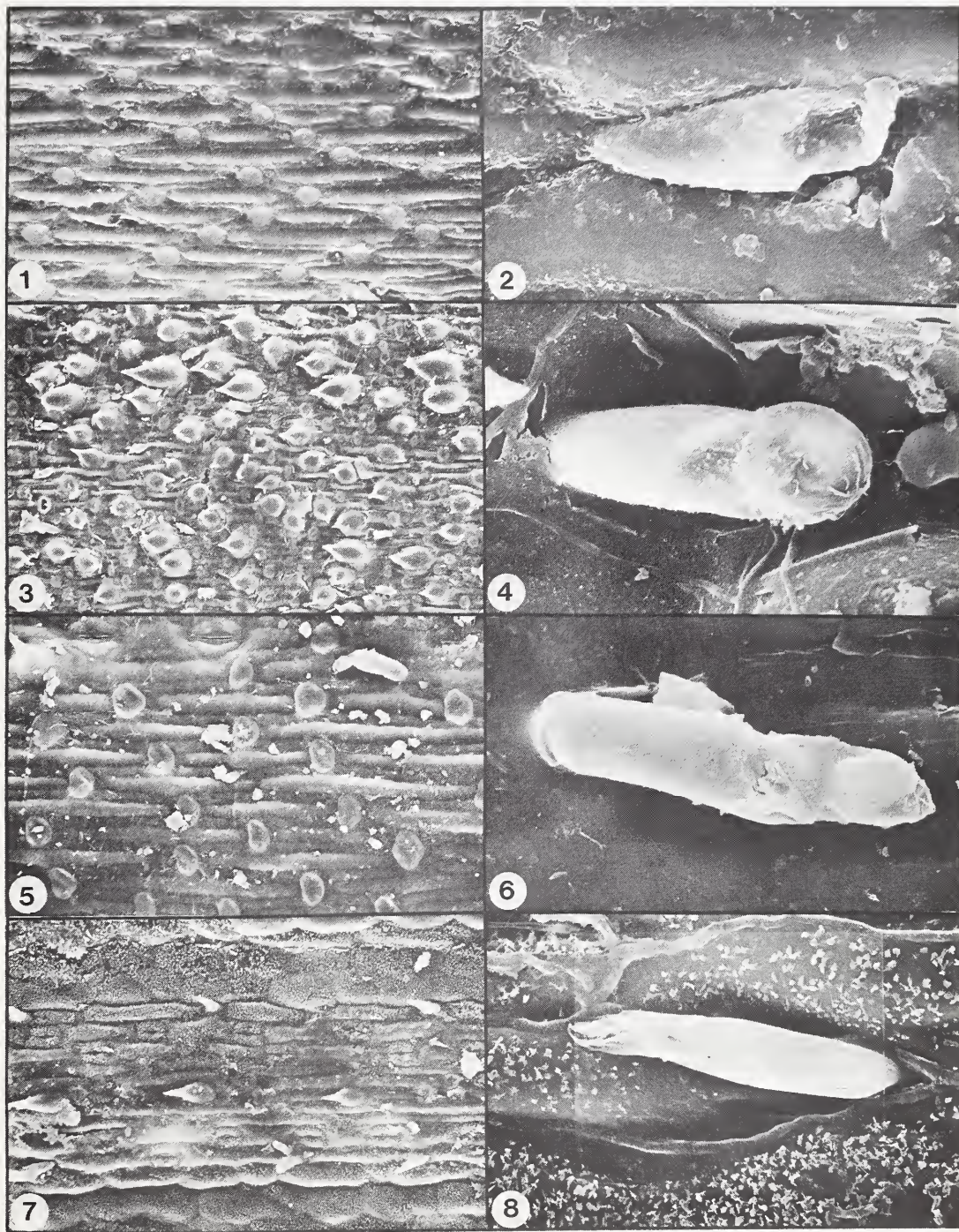


FIGURE 12.—Scanning electron micrographs of the abaxial epidermis of *Ehrharta setacea*. 1–2, *E. setacea* subsp. *setacea*, Ellis 4679: 1, all intercostal long cells interspaced by single, raised and rounded silica body, $\times 200$; 2, microhair with distal cell collapsed, $\times 1000$. 3–6, *E. setacea* subsp. *scabra*. 3–4, Ellis 4652: 3, prickles and asperites separating individual long cells, $\times 60$; 4, microhair with short, inflated distal cell, $\times 1000$. 5–6, Ellis 4653: 5, epidermis with few prickles, long cells separated by silica bodies and stomatal files present, $\times 200$; 6, microhair with slightly elongated distal cell, $\times 1000$. 7–8, *E. setacea* subsp. *uniflora*, Ellis 4670: 7, clear zonation with stomatal files and mid-intercostal long cells slightly inflated, $\times 100$; 8, microhair with tapering distal cell, $\times 1000$.

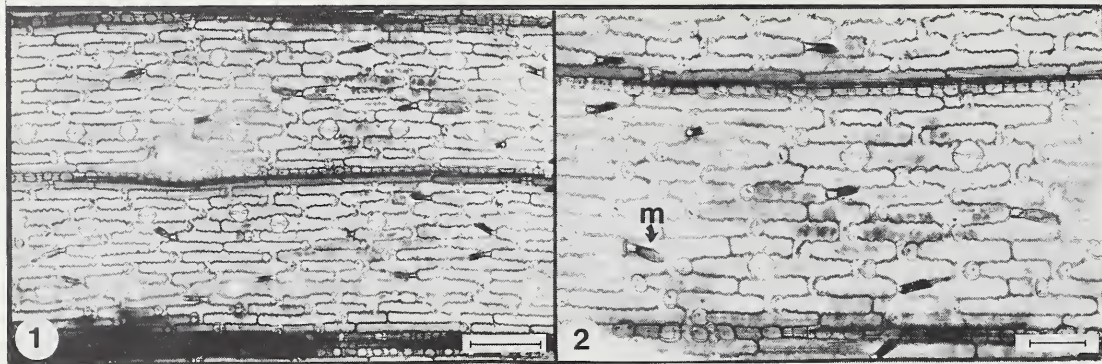


FIGURE 13.—Abaxial epidermis of *Ehrharta setacea* subsp. *disticha*, Williams 3086. 1, clearly differentiated costal and intercostal zones, scale = 10 μ m; 2, intercostal zones with microhairs (m) and stomata, scale = 10 μ m.

truly unfortunate that these valuable observations have had to wait over 30 years before being confirmed and published.

Tateoka (1963), on the other hand, also examined the leaf anatomy of several representatives of the Setacea group (*E. dodii*, *E. rupestris*, *E. setacea* and *E. trico-stata*) but reported that 'the mesophyll cells do not seem to have an arm (a projection of cell membranes), as far as the present author can observe'. The fact that no *Ehrharta* species were seen to possess arm cells or complex midrib vasculature was used by Tateoka (1963) to convincingly argue the case for the phylogenetic separation of the Ehrharteae and Oryzeae into different tribes and subfamilies. If he had been aware of the arm cells in the Setacea group, this reasoning would not have been nearly so sound and would probably never have been propounded.

The present paper proves beyond doubt, with substantiating photographic evidence, that arm cells, comparable to those in most Oryzeae, occur in some of the taxa of the Setacea group, *E. setacea* subsp. *scabra* in particular. These invaginations, together with chlorenchyma cell size, appear to become progressively reduced in most of the other taxa and are difficult to observe, even in freshly fixed, fully hydrated material. In reconstituted dried material the invaginations are apparently easier to see (Engelbrecht 1956) but may be overlooked as being artefacts due to dehydration and subsequent wall shrinkage.

The Setacea group of species is obviously a closely related unit with very uniform leaf anatomy. The degree of modification of the arm cells which appears to have occurred in the different taxa of the group is, consequently, most unexpected. Two entirely different types of modification appear to have taken place which deviate from the *E. setacea* subsp. *scabra* condition. *E. setacea* subsp. *uniflora* from lower altitudes with more equable climates and possibly higher levels of soil nutrients seems to have developed a diffuse mesophyll with an extensive air space system associated with the possession of abaxial stomata. No invaginations are evident in the chlorenchyma cell walls of taxa with this type of mesophyll and all intermediate stages can be distinguished. Taxa from the opposite type of habitat, from high altitudes with extremes of temperature and a low level of soil nutrients, on the other hand, have a very different type of leaf anatomy which appears to be derived from

the basic subsp. *scabra* anatomy. This type of anatomy is probably linked to the perennial nature of these leaves and is characterized by the mesophyll cells becoming increasingly reduced in size until they are small, straight-walled and isodiametric with a corresponding almost total reduction in the air space system. This anatomical type is always associated with a setaceous type of leaf and with the absence of stomata. A clear reduction series is evident in *E. rupestris* and these two very different mesophyll structures can possibly be interpreted as different derivations of the *E. setacea* subsp. *scabra* type of anatomy. It may be relevant to this argument that *E. setacea* subsp. *scabra* itself is limited to the east of the range of most of the taxa of the Setacea group where summer rainfall becomes a significant factor. It can be postulated that the loss of the arm cell invaginations may be an adaptation to winter rainfall.

These two different anatomical types in the Setacea group mirror the situation prevailing in many of the Danthonieae of the Cape Fynbos region. Taxa from high altitudes, such as *Merxmuellera*, *Pseudopentameris* and *Pentameris* (Ellis 1980, 1985a,b,c), resemble the latter type, whereas species from the lowland Fynbos areas, such as some species of *Plagiochloa* and *Lasiochloa*, have a more diffuse type of mesophyll. It appears, therefore, that habitat has been more significant than phylogenetic relationships in the evolution of these anatomical features of the leaf blades in many Cape Fynbos grass taxa.

The fact that the typical arm cell type in the mesophyll of *E. setacea* subsp. *scabra* appears to be modified so easily suggests that caution must be exercised in attaching too much taxonomic significance to the presence of this single character. Watson *et al.* (1985) discuss the occurrence of arm cells in the family. They rightly consider them to be a feature of high taxonomic value but point out that they can occur sporadically in distant, unrelated groups. No satisfactory explanation can be given for this type of distribution. The presence of arm cells in the Setacea group of *Ehrharta* does not necessarily imply bambusoid affinities, particularly as they are not accompanied by fusoids and complex midrib vasculature. Rather, arundinoid links are suggested by the type of mesophyll seen in *E. setacea* subsp. *setacea* (Tateoka 1963) and perhaps the arundinoid type of leaf anatomy could have been derived in a similar manner to that described in the Setacea group of *Ehrharta* from a primitive bambusoid-like ancestor possessing arm cells. The

Setacea group, therefore, can be viewed as a primitive arundinoid type exhibiting some links to the peripheral groups of the bambusoids.

CONCLUSIONS

In both leaf anatomy and spikelet morphology the Setacea group differs more from all the other groups of *Ehrharta* than any of these differ from each other. Apart from arm cells, many other anatomical characters separate the Setacea group from the other groups (Gibbs Russell & Ellis 1987). Examples are microhair and silica body shape. Furthermore no anatomical intermediates were found linking this group to any of the other equivalent groups of *Ehrharta*. These other groups, on the other hand, are sometimes linked by intermediate specimens or taxa. This suggests that the Setacea group may deserve separate subgeneric or generic status but consideration of the generic and infrageneric classification of *Ehrharta* will be dealt with in the last of this series of papers.

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Six cultivars of *Solanum macrocarpon* (Solanaceae) in Ghana

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Keywords: crop evolution, egg plant, Ghana, new cultivars, *Solanum dasyphyllum*, *Solanum macrocarpon* complex

ABSTRACT

The *Solanum macrocarpon* complex (the cultivated egg plant) has been studied in Ghana using morphological and experimental methods. Six cultivars belonging to the *S. macrocarpon* complex have been recognized and described. The cultivars are *S. macrocarpon* 'Gboma', *S. macrocarpon* 'Mankessim', *S. macrocarpon* 'Akwaseho', *S. macrocarpon* 'Kade', *S. macrocarpon* 'Sarpeiman' and *S. macrocarpon* 'Bui'. The very spiny, hairy plant traditionally called *S. dasyphyllum* is regarded as the wild ancestor from which the cultivars have been derived through a process of crop evolution. The variation within *S. macrocarpon* complex is attributable to genotypic differences and environmental factors.

UITTREKSEL

Die *Solanum macrocarpon*-kompleks (die gekweekte eierplant) is in Ghana bestudeer deur gebruik te maak van morfologiese en eksperimentele metodes. Ses kultivars wat aan die *S. macrocarpon*-kompleks behoort, is erken en beskryf. Die kultivars is *S. macrocarpon* 'Gboma', *S. macrocarpon* 'Mankessim', *S. macrocarpon* 'Akwaseho', *S. macrocarpon* 'Kade', *S. macrocarpon* 'Sarpeiman' en *S. macrocarpon* 'Bui'. Die baie doringrige, harige plant wat tradisioneel *S. dasyphyllum* genoem word, word as die wilde voorouer waaruit die kultivars deur 'n proses van gewas-evolusie ontstaan het, beskou. Die variasie binne die *S. macrocarpon*-kompleks kan toegeskryf word aan genotipiese verskille en omgewingsfaktore.

INTRODUCTION

Solanum macrocarpon L. is an important native African vegetable, especially in west Africa where both the leaves and fruits are eaten. In east Africa, particularly Uganda, it is however a minor crop and it is mainly the leaves that are eaten (Bukenyi 1984). The crop is also cultivated in South America and Asia. It was introduced to Europe from India, described and illustrated by Miller (1759) and named by Linnaeus (1771).

Despite its importance as a vegetable and its widespread occurrence, little has been done until now to recognize and describe any of the cultivars.

METHODS AND MATERIALS OF MORPHOLOGICAL STUDY

Materials belonging to the *S. macrocarpon* complex were collected from different localities throughout southern Ghana, and also (mainly seeds) obtained from elsewhere in Africa (Togo, Nigeria and Uganda). In southern Ghana, farms where *S. macrocarpon* is grown, were visited. Herbarium specimens were made. Ripe fruits, from which seeds were later extracted, were collected from farms and in some cases from markets. Occasionally, when mature fruits were not available, transplants were collected and later replanted in an experimental garden. Photographs of flowering and fruiting plants were taken.

Each individual (transplant) or each fruit was given a different accession number. In the laboratory, seeds from different accessions were extracted and spread on paper to dry at room temperature. After drying a mini-

mum of 20 seeds from each accession (fruit), they were sown in compost soil in seed pots. Pots were housed in a greenhouse at a mean daily maximum temperature of 34.8 °C and mean daily minimum temperature of 22.1 °C. Pots were watered every two to three days. When seedlings were at the three-leaved stage (about two weeks after germination), they were picked out of the seed pots and transferred to seed boxes kept outside in sunshine. When the plants were about a month old they were removed from the seed boxes and planted in the experimental garden.

About ten plants of each accession were planted. The plots were constantly weeded and plants watered when necessary. The major pests of the plants (caterpillars) were controlled by spraying with DDT (Five grammes of powder in about four litres of water).

The morphological characteristics of the plants were observed in their developmental process. When plants had fully grown, measurements of the characters of stem, leaves, flowers and fruits were taken.

The following accessions were studied:

S. macrocarpon 'Gboma'

Hall & Bukenyi S32 & S35 (Ghana, Pamproase, nr Achimota); Hall & Bukenyi S34 (Ghana, Sarpeiman, nr Achimota); Hall & Bukenyi S39 (Ghana, Avenor, nr Accra); Hall S54 (Togo, Lome); Hall S55 (Togo, Klevé); Hall S56 (Nigeria, Lagos Campus); Hall & Bukenyi S58, (Ghana, Accra market); Hall 47172 (Ghana, Medina, nr Accra).

S. macrocarpon 'Mankessim'

Hall & Bukenyi 47124 (Ghana, Mankessim); Hall 47170 & 47171 (Ghana, Nkwanta village).

S. macrocarpon 'Akwaseho'

Hall & Bukenyi S21 (Ghana, Akwaseho, Kwahu).

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S. macrocarpon 'Kade'

Hall 47169 (Ghana, Kade).

S. macrocarpon 'Sarpeiman'

Hall & Bukenya S45 & S47 (Ghana, Sarpeiman).

S. macrocarpon 'Bui'

Hall & Swaine 46212 (Ghana, Bui N. P.); Sobey 45080 (Ghana, Mole Game Reserve).

S. dasyphyllum var. *dasyphyllum* (the putative wild ancestor)

Anoff s.n. (Ghana, Nsawam); Morton 7484 (Ghana, nr Gambaga); Katiende UG. 2 (Uganda, Kampala).

The above specimens were deposited in University of Ghana Herbarium.

RESULTS

A summary of morphological measurements is given in Tables 1-4.

TABLE 1.—Summary of means of leaf characters. Each figure represents a mean of no less than 20 measurements

	Length (mm)	Width (mm)	L/W	No. of lobes	Leaf lobe depth ÷ leaf width	Leaf length ÷ petiole length
<i>S. macrocarpon</i> 'Gboma'	279	186	1,5	5	0,2	9,6
<i>S. macrocarpon</i> 'Mankessim'	270	150	1,8	4	0,3	16,1
<i>S. macrocarpon</i> 'Akwaseho'	353	237	1,5	8	0,2	35,0
<i>S. macrocarpon</i> 'Kade'	260	156	1,7	4	0,5	31,0
<i>S. macrocarpon</i> 'Sarpeiman'	275	148	1,9	4	0,1	8,9
<i>S. macrocarpon</i> 'Bui'	210	180	1,1	4	0,4	7,7
<i>S. dasyphyllum</i> var. <i>dasyphyllum</i> (putative wild ancestor)	198	145	1,4	5	0,4	26,0

TABLE 2.—Summary of means of mature fruit characters (mm). Each figure represents a mean of no less than 20 measurements

	L	W	L/W	Calyx length	Calyx width	Calyx L/W
<i>S. macrocarpon</i> 'Gboma'	38	48	0,80	31	13	2,6
<i>S. macrocarpon</i> 'Mankessim'	45	55	0,82	25	14	1,8
<i>S. macrocarpon</i> 'Akwaseho'	54	88	0,60	91	32	2,8
<i>S. macrocarpon</i> 'Kade'	50	65	0,77	30	10	3,0
<i>S. macrocarpon</i> 'Sarpeiman'	42	53	0,80	32	14	2,3
<i>S. macrocarpon</i> 'Bui'	35	40	0,88	25	10	2,5
<i>S. dasyphyllum</i> var. <i>dasyphyllum</i> (putative wild ancestor)	37	42	0,88	27	12	2,3

TABLE 3.—Summary of means of inflorescence characters. Each figure represents a mean of no less than 20 measurements

	Number of flowers	Length of axis (mm)	Length of peduncle (mm)	Length of pedicel (mm)
<i>S. macrocarpon</i> 'Gboma'	4	8,9	0,5	15,1
<i>S. macrocarpon</i> 'Mankessim'	5	11,7	0	7,7
<i>S. macrocarpon</i> 'Akwaseho'	8	—	—	—
<i>S. macrocarpon</i> 'Kade'	3	0,6	0,6	28,7
<i>S. macrocarpon</i> 'Sarpeiman'	6	10,5	0	49,0
<i>S. macrocarpon</i> 'Bui'	5	5,0	0	6,5
<i>S. dasyphyllum</i> var. <i>dasyphyllum</i> (putative wild ancestor)	5	8,7	0	14,7

TABLE 4.—Summary of means of characters of hermaphrodite flowers (mm). Each figure represents a mean of no less than 20 measurements

	Calyx Length	Calyx width	Calyx L/W	Corolla length	Corolla L/W	Anther length	Style length
<i>S. macrocarpon</i> 'Gboma'	16,0	6,0	2,7	25,0	1,6	6,5	8,0
<i>S. macrocarpon</i> 'Mankessim'	23,0	6,0	4,0	22,0	1,6	7,0	—
<i>S. macrocarpon</i> 'Akwaseho'	60,0	30,0	2,0	30,0	—	—	—
<i>S. macrocarpon</i> 'Kade'	29,5	5,5	5,4	27,5	—	10,0	10,5
<i>S. macrocarpon</i> 'Sarpeiman'	11,5	6,5	2,0	20,5	1,8	6,0	8,0
<i>S. macrocarpon</i> 'Bui'	10,0	5,0	2,0	15,0	—	6,0	9,0
<i>S. dasyphyllum</i> var. <i>dasyphyllum</i> (putative wild ancestor)	11,5	4,5	2,6	18,0	1,9	6,5	8,5

DISCUSSION AND CONCLUSIONS

The results of morphological study show that there is tremendous variation within the *S. macrocarpon* complex. Some of the accessions within the complex have big, deeply lobed leaves while others have small and less lobed leaves. Also flowers vary in their size and depth of corolla lobing. Whereas the flower calyx length of many accessions was 10–22 mm, one accession had a calyx length of about 60 mm; whereas the ratio between lamina length and petiole length of many accessions was 8–10, a ratio of 25–46 was obtained in one accession.

Apart from the above morphological variation, considered to be due mainly to genotypic differences, environmental factors were also seen to play a significant part in the phenotypic variation in the *S. macrocarpon* complex. One such factor was noted to be cultivation methods. For example, at Avenor near Accra in Ghana, *S. macrocarpon* was seen to be grown in crowded rows and the leaves were removed constantly for sale when the plants were still young. Figure 1 shows a typical planting of *S. macrocarpon* on a farm at Avenor. The plants here had a height of less than 0.3 m, and they had small fruits (30–35 mm diam.) and small leaves (170 × 90 mm). When seeds collected from a farm at Avenor were grown in our experimental farm with proper spacing of plants and no trimming, the plants attained a height of about 0.7 m with a fruit diameter of 40–60 mm and a mean leaf size of 255 × 164 mm.



FIGURE 1.—A typical planting of *Solanum macrocarpon* on a farm at Avenor near Accra, July 1979.

It was Bitter (1923) who first realized the tremendous variation within the *S. macrocarpon* complex and he described several infraspecific taxa. He also noted that the traditional separation of *S. macrocarpon* from *S. dasyphyllum* on the basis of the latter being spiny and hairy and the former unarmed and glabrous, was not satisfactory. He was for example able to describe, 'a spineless variety of *S. dasyphyllum* and a spiny subspecies of *S. macrocarpon*'.

We noted that there was a continuous range of variation in hairiness and spininess from very hairy and spiny accessions to glabrous and unarmed accessions. It also appears that spininess is a heterozygous character. This was demonstrated by the fact that when seeds from a single fruit (*Katende UG.1* — *S. macrocarpon*) were sown, about 60 % of the plants that grew were spiny and 40 % not spiny. Some plants of accession *Hall 47172* (*S.*

macrocarpon) from Medina near Accra, were seen to bear spines, though *S. macrocarpon*, according to most authors, is non-spiny.

The type specimen of *S. macrocarpon* is *Thonning 117* from Guinea [Ghana]. We have studied the IDC microfiche photographs of two duplicates on IDC microfiche No. 2203–101: III. 3–6. The specimen illustrated in III. 3 is glabrous, leaves oblong and subentire and that in III. 5 is glabrous, leaves oblong. Some of the leaves on this specimen are subentire while others are more or less deeply double-lobed with major lobes bearing minor lobes. The type specimens for *S. dasyphyllum*, *Thonning 144*, came from 'Guinea' (i.e. near Accra, Ghana (Hepper 1976). The IDC microfiche photographs (No. 2203–102: I. 1–4) show that the plants have oblong, deeply double-lobed leaves. They are very hairy and the stem, midribs and primary lateral nerves bear robust spines.

Bitter (1923) and recent other workers like Heine (1963) realized that the two species are very close.

Bukenya (1980 in unpublished M.Sc. thesis) concluded that the species traditionally called *S. macrocarpon* and *S. dasyphyllum* were one and proposed to sink the latter under *S. macrocarpon*.

In this paper we have treated the *S. macrocarpon* complex as a combination of the former two species, i.e. *S. macrocarpon* L. and *S. dasyphyllum* Schum. & Thonn.

Our study has enabled us to identify seven groups belonging to the *S. macrocarpon* complex. Since this complex is basically a cultivated crop, it is not satisfactory to give formal taxonomic ranks to these groups. We have therefore decided to give cultivar names to all these groups, except one which is wild. The wild one matches Bitter's *S. dasyphyllum* var. *dasyphyllum* in its dense spines and hairs and double lobing of the leaves. We believe that this wild plant is the ancestor of the cultivars and that the cultivars have arisen after a long process of cultivation and selection for non-spininess and non-hairiness. The name cultivar is used in this context in the same sense as used in the International Code of Nomenclature for Cultivated Plants of 1969.

The cultivar names are either the Ghanaian native names for the plants or names of localities where the cultivars were collected in Ghana. An attempt was made to compare the present cultivars with the taxa that Bitter (1923) described in Series *Macrocarpon*.

The following are the named cultivars with their descriptions and illustrations, where possible.

1. *S. macrocarpon* 'Gboma' (Figure 2)

Plant of low growth, not spiny. *Flowers* and *calyx* small; calyx 15–18 × 4–6 mm. *Leaves* petiolate, more or less glabrous, occasionally with a few scattered simple hairs, very shallowly lobed, middle lobe 20–40 mm long. *Stem* glabrous. *Fruit* medium-sized, 30–40 × 40–50 mm, green or white when young, turning purplish later; yellow when ripe. *Locality*: Ghana, Avenor near Accra, 5°33'N, 0°13'W, *Hall & Bukenya S39*.

This cultivar is comparable to Bitter's *S. macrocarpon* var. *macrocarpon* (var. *culvum*). Type: Guinea [Ghana], Thonning 117.



FIGURE 2.—*Solanum macrocarpon* 'Gboma', growing at Legon, Ghana (Mar. 1980), showing rotate corolla.

2. *S. macrocarpon* 'Mankessim' (Figure 3)

Plants fairly tall, spiny or unarmed. *Calyx* fairly large, 20–25 × 6 mm. *Leaves* more or less sessile, fairly deeply lobed, middle lobe 40–60 mm long, puberulous with simple, sessile stellate and stalked stellate hairs. *Stem* with same pubescence as leaves. *Fruit* fairly large, 40–50 × 50–60 mm, white when young, yellow when ripe.

Locality: Ghana, Mankessim, 5°16'N, 1°01'W, Hall & Bukenya 47124.

This cultivar is comparable to Bitter's *S. macrocarpon* var. *primovestitum* except that 'Mankessim' may bear spines which are lacking in var. *primovestitum* and the former has more and persistent hairs. The locality of Bitter's *S. macrocarpon* var. *primovestitum* is on the coast of Mozambique.



FIGURE 3.—*Solanum macrocarpon* 'Mankessim', growing on a farm at Mankessim, Ghana (July 1979).

3. *S. macrocarpon* 'Akwaseho' (Figure 4)

Plants similar to 'Mankessim', spiny or not spiny, but leaves more deeply lobed, middle lobe up to 70 mm long and fruits larger: about 50 × 90 mm. *Leaves* sessile with some simple and sessile stellate hairs. *Calyx* very big, up to 60 × 30 mm. *Fruits* ivory-coloured when young, turning yellow when ripe.

Locality: Ghana, Akwaseho, 6°37'N, 0°49'W, Hall & Bukenya S21.

This cultivar is comparable to Bitter's *S. macrocarpon* var. *macrocarpon* forma *megistocalyx* Bitter, in the form of the big calyx. The calyx of our cultivar is even bigger than in forma *megistocalyx*. The major difference is that 'Akwaseho' has some sessile stellate hairs and spines may be present on leaves while forma *megistocalyx* lacks hairs and spines. The locality of forma *megistocalyx* was Congo (Lower Zaire) Region, Kisantu, Gillet s.n.



FIGURE 4.—*Solanum macrocarpon* 'Akwaseho', growing in an experimental plot at Legon, Ghana (Nov. 1979), showing big fruits, big fruiting calyx and deeply lobed leaves.

4. *S. macrocarpon* 'Kade' (Figure 5)

Leaves very narrow and deeply lobed, middle lobe up to 80 mm long; sessile with simple, sessile stellate or stalked stellate hairs. *Calyx* fairly long but narrow, up to 30 × 60 mm. *Fruit* ovoid or spherical, 30–70 × 40 mm, green or green with patches when young, turning yellow when ripe.

Locality: Ghana, Abodon, 6°26'N, 1°32'W, Hall 47169.

This cultivar does not match any of Bitter's taxa. It is unique in that its leaves are so narrow and deeply lobed and it may have an oblong fruit which is unusual in *S. macrocarpon*.



FIGURE 5.—*Solanum macrocarpon* 'Kade', growing on a farm at Abodon, Ghana (July 1979).

5. *S. macrocarpon* 'Sarpeiman' (Figure 6)

Plants similar to 'Gboma' but almost always spiny and fairly hairy with simple, branched, sessile stellate and

stalked stellate hairs on leaves and stem. *Leaves* petiolate. *Fruit* green when young, turning yellow when ripe.

Locality: Ghana, Sarpeiman, 5°43'N, 0°18'W, Hall & Bukenya S45.

This cultivar is comparable to Bitter's *S. dasyphyllum* var. *semiglabrum* (C. W. Wright) Bitter, except that in the former the spine length on the midrib ranges from 0–13 mm whereas in the latter the range is 6–10 mm. The type locality of *semiglabrum* is Nupe-Benue Province in northern Nigeria.



FIGURE 6.—*Solanum macrocarpon* 'Sarpeiman', growing in an experimental plot at Legon, Ghana (Nov. 1979) showing spines.

6. *S. macrocarpon* 'Bui'

Plants spiny. *Leaves* subsessile and deeply lobed, middle lobe 60–70 mm long; with sparse, simple, branched, sessile and stalked stellate hairs. *Stem* with similar pubescence as leaves but denser. *Fruit* green when young, turning yellow when ripe.

Locality: Ghana, Bui, 8°16'N, 2°16'W, Hall & Swaine 46212.

This cultivar is comparable to Bitter's *S. dasyphyllum* var. *dasyphyllum* except that the former is less hairy than the latter, probably because the former is occasionally cultivated. Bitter's locality of var. *dasyphyllum* is Guinea [Ghana], Thonning 144.

7. Putative wild ancestor (Figure 7)

Plants very hairy and very spiny. *Leaves* subsessile, often doubly lobed; middle lobe up to 60 mm long. *Ca-*



FIGURE 7.—Putative wild ancestor (*Solanum dasyphyllum* var. *dasyphyllum*) from Uganda, growing in cultivation at Legon, Ghana (Mar. 1980), showing mature, deeply lobed leaf with numerous spines and hairs.

lyx about 10 × 5 mm. *Leaves* and *stem* with simple, branched, sessile or stalked stellate hairs. *Fruit* green when young, turning light yellow when ripe.

Locality: Uganda, near Kampala, Katende UG.2; Ghana, Nsawam, Anoff s.n.

This is comparable to Bitter's *S. dasyphyllum* var. *dasyphyllum* from Guinea [Ghana] Thonning 144.

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Bibliography of *Fusarium* (Fungi: Hyphomycetes) in South Africa, 1945-1985

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Keywords: bibliography, *Fusarium*, Fungi, Hyphomycetes, South Africa

ABSTRACT

A taxonomic study of the genus *Fusarium* in South Africa was published by Doidge in 1938. A record of all the fungi, including *Fusarium*, known to occur in South Africa, and of the literature concerning them until the end of 1945, was compiled by Doidge in 1950. The present bibliography attempts to provide an index to all the literature on *Fusarium* in South Africa published after 1945 until the end of 1985. An alphabetical list of *Fusarium* species is provided and the hosts and/or substrates from which each species has been recorded are listed alphabetically together with references to the literature cited. A separate alphabetical list of hosts and substrates together with the *Fusarium* species recorded on each is also included.

UITTREKSEL

'n Taksonomiese studie van die genus *Fusarium* in Suid-Afrika is in 1938 deur Doidge gepubliseer. In 1950 het Doidge al die fungi, waaronder *Fusarium*, wat in Suid-Afrika bekend is en die toepaslike literatuur tot aan die einde van 1945, aangeteken. Die huidige bibliografie poog om 'n indeks te voorsien tot al die literatuur oor *Fusarium* in Suid-Afrika wat na 1945 tot aan die einde van 1985 gepubliseer is. 'n Alfabetiese lys van *Fusarium*-spesies word voorsien en die gashere en/of substrate waarop elke spesie aangeteken is, word in 'n alfabetiese lys aangegee tesame met verwysings na die betrokke literatuur. 'n Aparte alfabetiese lys van gashere en substrate tesame met die *Fusarium*-spesies wat op elk aangeteken is, word ook ingesluit.

INTRODUCTION

A major taxonomic study of the genus *Fusarium* in South Africa was published by Doidge (1938). In this publication a detailed account was given of the occurrence of 26 species, 31 varieties, and 13 formae of *Fusarium* on a large number of host plants, as well as insects and other fungi. Doidge (1950) compiled a record of all the fungi and lichens known to occur in South Africa and of the literature concerning them, until the end of 1945. This monumental compilation included some 29 species, 25 varieties, and 11 formae of *Fusarium*. These two publications are the basis of all the existing knowledge about the occurrence of the genus *Fusarium* in South Africa. Several subsequently published lists of plant diseases in South Africa (Doidge *et al.* 1953; Gorter 1961, 1973, 1977, 1981) have added some information about the occurrence of *Fusarium* spp. as plant pathogens in South Africa, but did not include the literature dealing with the occurrence of *Fusarium* spp. as saprophytes or mycotoxin producers in South Africa.

The aim of the present publication is to compile an index to all the available literature on *Fusarium* in South Africa published after 1945, and thus not included in Doidge (1950), to the end of 1985. In addition to phyto-

pathological aspects, the literature surveyed included mycological, mycotoxicological, and ecological studies. A few references to papers published prior to 1945 but not cited by Doidge (1950) are included. It is hoped that this bibliography, together with Doidge (1938) and Doidge (1950), will be as complete a guide as possible to the literature on *Fusarium* in South Africa to the end of 1985.

The material in this bibliography is arranged in three parts: References; *Fusarium* species; Hosts and substrates.

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FUSARIUM SPECIES

The *Fusarium* species are arranged alphabetically and the hosts and/or substrates from which each species has been recorded are listed alphabetically under that species together with references to the literature cited. The system of taxonomy and nomenclature of *Fusarium* used is that of Nelson *et al.* (1983). In cases where the names of *Fusarium* species used in the literature cited cannot be accommodated according to this system, e.g. *F. roseum*, the name is indexed as used in the relevant publication(s) with a note that the identity is uncertain. In cases where the names used in the literature cited are considered to be synonyms of the names accepted by Nelson *et al.* (1983), these names are cited as synonyms under each species and are also cross-referenced in the alphabetical list, e.g. *F. verticillioides* (Sacc.) Nirenberg is considered to be a synonym under *F. moniliforme* Sheldon, but is also included in the alphabetical list under *F. verticillioides* with a note to 'see *F. moniliforme*'. In no case did the present authors attempt to confirm the identity of any of the *Fusarium* species or the hosts referred to in the literature cited. The names of the host plants are given as in the original reference.

acuminatum Ell. & Ev.

- Conifers: Darvas *et al.* (1978)
- Eleusine* sp.: Kellerman *et al.* (1980)
- Medicago sativa*: Marasas & Bredell (1973); Thompson (1985)
- Medicago* spp.: Lamprecht *et al.* (1984)
- Panicum coloratum*: Kellerman *et al.* (1980)
- Pastures: Kellerman *et al.* (1980)
- Pennisetum typhoides*: Rabie *et al.* (1982)
- Sorghum caffrorum*: Rabie *et al.* (1982)
- Tribulus terrestris*: Kellerman *et al.* (1980)
- Triticum aestivum*: Kellerman *et al.* (1980)

aquaeductuum (Radlk. & Rabenh.) Lagerh.

= *aquaeductuum* (Radlk. & Rabenh.) Lagerh. var. *medium* Wollenw.

- Conifers: Darvas *et al.* (1978)

aquaeductuum var. *medium* (See *aquaeductuum*)

avenaceum (Fr.) Sacc.

- Hordeum vulgare*: Rabie *et al.* (1982)
- Medicago* spp.: Lamprecht *et al.* (1984)
- Panicum coloratum*: Eicker (1976)
- Pastures: Kellerman *et al.* (1980)
- Soil: Eicker (1969)
- Sorghum caffrorum*: Rabie & Lübben (1984); Rabie & Thiel (1985)
- Triticum aestivum*: Putterill (1954)

chlamydosporum Wollenw. & Reinking

- = *chlamydosporum* Wollenw. & Reinking var. *fuscum* Gerlach
- = *fusarioides* (Frag. & Cif.) Booth
- Aspalathus linearis*: Engelbrecht *et al.* (1983)
- Cynodon lemfuensis*: Gerlach & Nirenberg (1982)
- Pastures: Kellerman *et al.* (1980)
- Pennisetum typhoides*: Kriek & Marasas (1983); Marasas *et al.* (1984a); Rabie *et al.* (1975, 1982)
- Phaseolus vulgaris*: Marasas *et al.* (1984a); Rabie *et al.* (1978)
- Sorghum caffrorum*: Rabie & Lübben (1984); Rabie & Thiel (1985); Rabie *et al.* (1978, 1982)
- Tribulus terrestris*: Kellerman *et al.* (1980)
- Zea mays*: Kriek & Marasas (1983); Marasas (1982); Marasas *et al.* (1981)

chlamydosporum var. *fuscum* (See *chlamydosporum*)

ciliatum Lk.

- Epichloë zahlbruckneriana*: Gerlach & Nirenberg (1982)

concolor Reinking (Identity uncertain)

- Pennisetum typhoides*: Gerlach & Nirenberg (1982); Rabie *et al.* (1982)
- Pyrus malus*: Combrink *et al.* (1985)
- Sorghum caffrorum*: Rabie & Lübben (1984); Rabie & Thiel (1985)

crookwellense Burgess, Nelson & Toussoun

- Panicum laevifolium*: Burgess *et al.* (1982)
- Triticum aestivum*: Burgess *et al.* (1982)

culmorum (W. G. Smith) Sacc.

- Conifers: Darvas *et al.* (1978)
- Eleusine* sp.: Kellerman *et al.* (1980)
- Panicum coloratum*: Kellerman *et al.* (1980)
- Pastures: Kellerman *et al.* (1980)
- Persea americana*: Darvas & Kotzé (1981)
- Soil: Eicker (1969, 1970b); Smith *et al.* (1984)
- Triticum aestivum*: CMI (1984a); Jooste (1965); Kellerman *et al.* (1980); Maas & Kotzé (1981); Scott (1980); Smith *et al.* (1984)

decemcellulare Brick

- Persea americana*: Darvas (1978); Darvas & Kotzé (1979, 1981)

dlamini Marasas, Nelson & Toussoun

- Soil: Marasas *et al.* (1985a)

equiseti (Corda) Sacc.

- Arachis hypogaea*: Martin *et al.* (1971)
- Conifers: Darvas *et al.* (1978)
- Cucumis melo*: Reuveni (1985)
- Lycopersicon esculentum*: Visser (1980)
- Medicago sativa*: Thompson (1985)
- Medicago* spp.: Lamprecht *et al.* (1984)
- Pastures: Kellerman *et al.* (1980)
- Pennisetum typhoides*: Rabie *et al.* (1982)
- Soil: Eicker (1974, 1975); Papendorf (1976); Smith *et al.* (1984)
- Sorghum caffrorum*: Martin *et al.* (1971); Rabie & Lübben (1984); Rabie & Thiel (1985); Rabie *et al.* (1982)
- Triticum aestivum*: Maas & Kotzé (1985); Smith *et al.* (1984)
- Zea mays*: Kriek & Marasas (1983); Marasas (1982); Marasas *et al.* (1981)

equiseti var. *longipes* (See *longipes*)

fusarioides (See *chlamydosporum*)

graminearum Schwabe

- Medicago* spp.: Lamprecht *et al.* (1984)
- Panicum coloratum*: Eicker (1976)
- Soil: Eicker (1976)
- Triticum aestivum*: Maas & Kotzé (1981); Oelofsen (1950); Scott (1980)
- Zea mays*: Aucock *et al.* (1980); Gelderblom *et al.* (1984b); Kriek & Marasas (1983); Krüger (1970a, 1970b, 1970c); Krüger & Jooste (1967); Krüger *et al.* (1965); Marasas (1982); Marasas *et al.* (1977, 1979a, 1979b, 1981, 1984a); Steyn (1933); Thiel *et al.* (1982); Watt & Breyer-Brandwijk (1962)

heterosporum Nees

- Trifolium subterraneum*: Mills (1984)

heterosporum Nees var. *congoense* (Wollenw.) Wollenw. (Identity uncertain)

- Grasses infected with ergot or smut: Gerlach & Nirenberg (1982)

lateritium Nees

- = *lateritium* Nees var. *longum* Wollenw.
- = *stilboides* Wollenw.
- Citrus spp.: Booth (1971); Gerlach & Nirenberg (1982); Gordon (1960)
- Coffea* spp.: Gerlach & Nirenberg (1982)

lateritium var. *longum* (See *lateritium*)

longipes Wollenw. & Reinking

- = *equiseti* (Corda) Sacc. var. *longipes* (Wollenw. & Reinking) Joffe
- Eleusine* sp.: Kellerman *et al.* (1980)
- Panicum coloratum*: Kellerman *et al.* (1980)
- Triticum aestivum*: Kellerman *et al.* (1980)

lunulosporum Gerlach

- Citrus paradisi*: Gerlach (1977); Gerlach & Nirenberg (1982)

lycopersici (See *oxysporum* f. sp. *lycopersici*)

merismoides Corda

- Sorghum caffrorum*: Rabie & Lübben (1984); Rabie & Thiel (1985)

moniliforme Sheldon

- = *verticillioides* (Sacc.) Nirenberg
- Ananas comosus*: Edmonstone-Sammons (1957, 1958)
- Arachis hypogaea*: Van Warmelo (1967)
- Cereals: Scott (1965); Van Rensburg *et al.* (1971)

- Conifers: Darvas *et al.* (1978)
 Feeds: Van Warmelo (1967)
 Hay: Van Warmelo (1967)
 Legumes: Scott (1965); Van Rensburg *et al.* (1971)
Medicago sativa: Van Warmelo (1967)
Musa spp.: Swarts (1978)
Oryza sativa: Gorter (1977)
Panicum coloratum: Eicker (1976)
 Pastures: Kellerman *et al.* (1980)
Pennisetum typhoides: Marasas *et al.* (1984a); Rabie *et al.* (1982); Steyn *et al.* (1978)
Persea americana: Darvas (1979)
Phaseolus vulgaris: Van der Walt & Steyn (1943)
Saccharum officinarum: Booth (1971); CMI (1977b)
 Soil: Eicker (1969); Papendorf (1976)
Sorghum caffrorum: Rabie & Lübben (1984); Rabie & Thiel (1985); Rabie *et al.* (1982)
Tribulus terrestris: Kellerman *et al.* (1980)
Voandzeia subterranea: Martin *et al.* (1971)
Zea mays: Aucock *et al.* (1980); CMI (1977b); Coetzer *et al.* (1985); Du Toit (1968); Gelderblom *et al.* (1983, 1984a, 1984b, 1984c); Kellerman *et al.* (1972); Kriek & Marasas (1983); Kriek *et al.* (1981a, 1981b); Krüger (1970a, 1970b, 1970c, 1970d); Krüger & Jooste (1967); Krüger *et al.* (1965); Marasas *et al.* (1976, 1977, 1979a, 1979b, 1981, 1984a, 1984b, 1985b); Pienaar (1977); Pienaar *et al.* (1981); Russell & Berjak (1983); Russell *et al.* (1983); Steyn (1933, 1950); Steyn *et al.* (1979); Thiel *et al.* (1982); Van Warmelo (1967)
- moniliforme* var. *subglutinans* (See *subglutinans*)
- oxysporum** Schlecht. emend. Snyder. & Hans.
 = *oxysporum* Schlecht. var. *redolens* (Wollenw.) Gordon
Arachis hypogaea: Rabie *et al.* (1982)
Aspalathus linearis: Engelbrecht *et al.* (1983)
Chrysanthemum cinerariaefolium: Ingamells (1974)
Cichorium intybus: Du Toit & Ingamells (1972)
 Citrus spp.: Gordon (1960)
 Conifers: Darvas *et al.* (1978)
Cucumis melo: Ferreira & Knox-Davis (1984, 1985); Reuveni (1985)
Hordeum vulgare: Rabie *et al.* (1982)
 Man: Young & Meyers (1979)
Mangifera indica: Rijkenberg & Crookes (1985)
Medicago sativa: Thompson (1985)
Medicago spp.: Lamprecht *et al.* (1984)
Musa spp.: Deacon *et al.* (1985)
Narcissus pseudonarcissus: Gordon (1960); Wager (1972)
Panicum coloratum: Eicker (1976)
Persea americana: Darvas (1979)
 Soil: Darvas (1979); Eicker (1969, 1970a, 1970b, 1974, 1975); Papendorf (1976); Rijkenberg & Crookes (1985)
Sorghum caffrorum: Rabie & Lübben (1984); Rabie & Thiel (1985); Rabie *et al.* (1982)
Trifolium subterraneum: Mills (1984)
Vitis vinifera: Le Roux *et al.* (1973)
Zea mays: Du Toit (1968); Krüger (1970a, 1970b, 1970c, 1970d); Krüger & Jooste (1967)
- oxysporum** Schlecht. f. sp. *cepae* (Hanz.) Snyder. & Hans.
Allium cepa: Holz & Knox-Davis (1974, 1976, 1985a, 1985b, 1985c)
Oxalis pes-caprae: Holz & Knox-Davis (1976)
Oxalis zeekoevleyensis: Holz & Knox-Davis (1976)
- oxysporum** Schlecht. f. sp. *cubense* (E. F. Smith) Snyder. & Hans.
Musa spp.: CMI (1977a); Deacon (1984a, 1984b); Deacon *et al.* (1985); Swarts (1978)
- oxysporum** Schlecht. f. sp. *cucumerinum* Owen
Cucumis sativus: Booth (1971); CMI (1984b)
- oxysporum** Schlecht. f. sp. *lycopersici* (Sacc.) Snyder. & Hans.
 = *lycopersici* Bruschi
Lycopersicon esculentum: Hofmeyr *et al.* (1948); Holz (1976); Nel (1949); Visser (1980)
- oxysporum** Schlecht. f. sp. *melonis* Snyder. & Hans.
Cucumis melo: Ferreira & Knox-Davis (1984, 1985)
- oxysporum** Schlecht. f. sp. *niveum* (E. F. Smith) Snyder. & Hans.
Citrullus vulgaris: Booth (1971)
- oxysporum** Schlecht. f. sp. *phormii* Wager
Phormium tenax: Wager (1947)
- oxysporum** Schlecht. f. sp. *vasinfectum* (Atk.) Snyder. & Hans.
Gossypium spp.: Booth (1971)
- oxysporum* var. *redolens* (See *oxysporum*)
- poae** (Peck) Wollenw.
Saccharum officinarum: Booth (1971)
Zea mays: Kriek & Marasas (1983); Marasas (1982); Marasas *et al.* (1981)
- roseum** Link (Identity uncertain)
 Cereals: Scott (1965); Van Rensburg *et al.* (1971)
 Legumes: Scott (1965); Van Rensburg *et al.* (1971)
 Soil: Eicker (1975)
- sacchari* var. *subglutinans* (See *subglutinans*)
- sambucinum** Fuckel
Humulus lupulus: Gorter (1977)
Persea americana: Darvas (1978); Darvas & Kotzé (1979)
 Soil: Eicker (1974, 1975)
- scirpi** Lambotte & Fautr.
Medicago spp.: Burgess *et al.* (1985); Lamprecht *et al.* (1984)
 Soil: Burgess *et al.* (1985)
Sorghum caffrorum: Rabie & Lübben (1984)
Zea mays: (Krüger (1970a)
- scirpi** Lambotte & Fautr. var. *compactum* Wollenw. (Identity uncertain)
Sorghum caffrorum: Rabie & Lübben (1984); Rabie & Thiel (1985)
- semitectum** Berk. & Rav.
 Conifers: Darvas *et al.* (1978)
Musa sp.: Swarts (1978)
Pennisetum typhoides: Rabie *et al.* (1982)
 Soil: Eicker (1969)
Sorghum caffrorum: Martin *et al.* (1971); Rabie & Lübben (1984)
- solani** (Mart.) Appel & Wollenw. emend. Snyder. & Hans.
Chrysanthemum cinerariaefolium: Ingamells (1974)
Citrus limonia: Graham *et al.* (1985)
Crotalaria juncea: Hean (1947)
Cucumis melo: Reuveni (1985)
Hyacinthus sp.: Gordon (1960); Wager (1972)
 Insects: Gordon (1960)
Medicago sativa: Thompson (1985)
Persea americana: Darvas (1978); Darvas & Kotzé (1979)
 Soil: Eicker (1974, 1975); Papendorf (1976)
Sorghum caffrorum: Rabie & Lübben (1984); Rabie & Thiel (1985)
Trifolium subterraneum: Mills (1985)
Vitis vinifera: Le Roux *et al.* (1973)
Zea mays: Krüger (1970a)
- sp.** (See *Fusarium* species undetermined at end of this list)
- sporotrichioides** Sherb.
 Soil: Papendorf (1976)
Voandzeia subterranea: Kriek & Marasas (1983); Martin *et al.* (1971)
- stilboides* (See *lateritium*)
- subglutinans** (Wollenw. & Reinking) Nelson, Toussoun & Marasas
 = *moniliforme* Sheldon var. *subglutinans* Wollenw. & Reinking
 = *sacchari* (Butler) Gams var. *subglutinans* (Wollenw. & Reinking) Nirenberg
 Air: Crookes & Rijkenberg (1985a)
Ananas comosus: Gordon (1960)
 Conifers: Darvas *et al.* (1978)
Crotalaria juncea: Hean (1947)
Mangifera indica: Crookes & Rijkenberg (1985a, 1985b); Dieckman *et al.* (1982); Kotzé (1985)
Morus japonica: Crookes & Rijkenberg (1985a)
Saccharum officinarum: Booth (1971)
 Soil: Crookes & Rijkenberg (1985a); Rijkenberg & Crookes (1985)
Sorghum caffrorum: CMI (1978); Rabie & Lübben (1984); Rabie & Thiel (1985); Rabie *et al.* (1982)
Syzygium cordatum: Crookes & Rijkenberg (1985a)
Zea mays: Aucock *et al.* (1980); CMI (1978); Gelderblom *et al.* (1984b); Kriek & Marasas (1983); Kriek *et al.* (1977); Krüger *et al.* (1965); Marasas (1982); Marasas *et al.* (1977, 1979a, 1979b, 1981, 1984a); Steyn (1933); Steyn *et al.* (1978); Thiel (1978); Thiel *et al.* (1982); Watt & Breyer-Brandwijk (1962)
- verticillioides* (See *moniliforme*)

Fusarium species undetermined

- Ananas comosus*: Malan (1954)
Arachis hypogaea: Van Warmelo (1967)
 Cereals: Dutton & Westlake (1985)
 Conifers: Darvas *et al.* (1978)
Crotalaria juncea: Hean (1947)
Eleusine sp.: Kellerman *et al.* (1980)
 Feeds: Dutton & Westlake (1985); Van Warmelo (1967)
Glycine max: Dutton & Westlake (1985)
 Hay: Van Warmelo (1967)
Mangifera indica: Crookes & Rijkenberg (1985a)
Medicago sativa: Thompson (1985); Van Warmelo (1967)
Musa spp.: Deacon *et al.* (1985)

- Panicum coloratum*: Eicker (1976); Kellerman *et al.* (1980)
 Pastures: Kellerman *et al.* (1980)
Pennisetum clandestinum: Bryson (1982); Newsholme *et al.* (1983)
Pennisetum typhoides: Rabie *et al.* (1975)
 Soil: Crookes & Rijkenberg (1985a); Eicker (1969, 1970b, 1974, 1975); Van Wyk & Baard (1970)
Solanum tuberosum: Combrink & Prinsloo (1975); Combrink *et al.* (1975); Visser & Kotzé (1979)
Tribulus terrestris: Kellerman *et al.* (1980)
Triticum aestivum: Kellerman *et al.* (1980)
Zea mays: Du Toit (1969); Dutton & Westlake (1985); Krüger (1970a, 1970b); Krüger & Jooste (1967); Van Warmelo (1967)

HOSTS AND SUBSTRATES

The hosts and substrates are listed alphabetically and the *Fusarium* species recorded on each are listed alphabetically. References to the literature cited can be found under the relevant *Fusarium* species. The names of the host plants are given as in the original reference.

Air

- F. subglutinans*

Allium cepa L.

- F. oxysporum* f. sp. *cepa*

Ananas comosus (L.) Merr.

- F. moniliforme*
F. subglutinans
F. sp.

Arachis hypogaea L.

- F. equiseti*
F. moniliforme
F. oxysporum
F. sp.

Aspalathus linearis (Burm. f.) R. Dahlg.

- F. chlamydosporum*
F. oxysporum

Cereals

- F. moniliforme*
F. roseum
F. sp.

Chrysanthemum cinerariaefolium (Trev.) Bocc.

- F. oxysporum*
F. solani

Cichorium intybus L.

- F. oxysporum*

Citrullus vulgaris Schrad.

- F. oxysporum* f. sp. *niveum*

Citrus limonia Osbeck

- F. solani*

Citrus paradisi Macf.

- F. lunulosporum*

Citrus spp.

- F. lateritium*
F. oxysporum

Coffea spp.

- F. lateritium*

Conifers

- F. acuminatum*
F. aquaeductuum
F. culmorum
F. equiseti
F. moniliforme
F. subglutinans
F. oxysporum
F. semitectum
F. sp.

Crotalaria juncea L.

- F. solani*
F. subglutinans
F. sp.

Cucumis melo L.

- F. equiseti*
F. oxysporum

- F. oxysporum* f. sp. *melonis*

- F. solani*

Cucumis sativus L.

- F. oxysporum* f. sp. *cucumerinum*

Cynodon lemfuensis Vanderyst

- F. chlamydosporum*

Eleusine spp.

- F. acuminatum*
F. culmorum
F. longipes
F. sp.

Epichloë zahlbruckneriana P. Henn.

- F. ciliatum*

Feeds

- F. moniliforme*
F. sp.

Glycine max (L.) Merr.

- F. sp.*

Gossypium spp.

- F. oxysporum* f. sp. *vasinfectum*

Grasses infected with Ergot or Smut

- F. heterosporum* var. *congoense*

Hay

- F. moniliforme*
F. sp.

Hordeum vulgare L.

- F. avenaceum*
F. oxysporum

Humulus lupulus L.

- F. sambucinum*

Hyacinthus sp.

- F. solani*

Insects

- F. solani*

Legumes

- F. moniliforme*
F. roseum

Lycopersicon esculentum Mill.

- F. equiseti*
F. oxysporum f. sp. *lycopersici*

Man

- F. oxysporum*

Mangifera indica L.

- F. oxysporum*
F. subglutinans
F. sp.

Medicago sativa L.

- F. acuminatum*
F. equiseti

F. moniliforme
F. oxysporum
F. solani
F. sp.

Medicago spp.

F. acuminatum
F. avenaceum
F. equiseti
F. graminearum
F. oxysporum
F. scirpi

Morus japonica L.

F. subglutinans

Musa spp.

F. moniliforme
F. oxysporum
F. oxysporum f. sp. *cubense*
F. semitectum
F. sp.

Narcissus pseudonarcissus L.

F. oxysporum

Oryza sativa L.

F. moniliforme

Oxalis pescaprae L.

F. oxysporum f. sp. *cepaie*

Oxalis zeekoevleyensis R. Knuth

F. oxysporum f. sp. *cepaie*

Panicum coloratum L.

F. acuminatum
F. avenaceum
F. culmorum
F. graminearum
F. longipes
F. moniliforme
F. oxysporum
F. sp.

Panicum laevifolium Hack.

F. crookwellense

Pastures

F. acuminatum
F. avenaceum
F. chlamydosporum
F. culmorum
F. equiseti
F. moniliforme
F. sp.

Pennisetum clandestinum Hochst. ex Chiov.

F. sp.

Pennisetum typhoides (Burm.) Stapf & Hubbard

F. acuminatum
F. chlamydosporum
F. concolor
F. equiseti
F. moniliforme
F. semitectum
F. sp.

Persea americana Mill.

F. culmorum
F. decemcellulare
F. moniliforme
F. oxysporum
F. sambucinum
F. solani

Phaseolus vulgaris L.

F. chlamydosporum
F. moniliforme

Phormium tenax Forst.

F. oxysporum f. sp. *phormii*

Pyrus malus L.

F. concolor
F. lateritium

Saccharum officinarum L.

F. moniliforme
F. poae
F. subglutinans

Soil

F. avenaceum
F. culmorum
F. dlamini
F. equiseti
F. graminearum
F. moniliforme
F. oxysporum
F. roseum
F. sambucinum
F. scirpi
F. semitectum
F. solani
F. sporotrichioides
F. subglutinans
F. sp.

Solanum tuberosum L.

F. sp.

Sorghum caffrorum Beauv.

F. acuminatum
F. avenaceum
F. chlamydosporum
F. concolor
F. equiseti
F. merismoides
F. moniliforme
F. oxysporum
F. sambucinum
F. scirpi
F. scirpi var. *compactum*
F. semitectum
F. solani
F. subglutinans

Syzygium cordatum Hochst.

F. subglutinans

Tribulus terrestris L.

F. acuminatum
F. chlamydosporum
F. moniliforme
F. sp.

Trifolium subterraneum L.

F. heterosporum
F. oxysporum
F. solani

Triticum aestivum L.

F. acuminatum
F. avenaceum
F. crookwellense
F. culmorum
F. equiseti
F. graminearum
F. longipes
F. sp.

Vitis vinifera L.

F. oxysporum
F. solani

Voandzeia subterranea (L.) Thomas

F. moniliforme
F. sporotrichioides

Zea mays L.

F. chlamydosporum
F. equiseti
F. graminearum
F. moniliforme
F. oxysporum
F. poae
F. scirpi
F. solani
F. subglutinans
F. sp.

The genus *Rubus* (Rosaceae) in South Africa. IV. Natural hybridization

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Keywords: chromosomes, hybridization, polyploidy, reproduction, Rosaceae, *Rubus*, South Africa, speciation

ABSTRACT

The genus *Rubus* L. is represented in southern Africa by the subgenera *Eubatus* Focke and *Idaeobatus* Focke. A combination of morphological data, data on the reproductive systems of some collections and meiotic chromosome behaviour indicates that a hybrid swarm in the eastern Transvaal was formed subsequent to the hybridization between *R. cuneifolius* Pursh. taxon B (subgenus *Eubatus*) and *R. longepedunculatus* (C. E. Gust.) C. H. Stirton (subgenus *Idaeobatus*). Other examples of intra- and intersubgeneric hybridization were found during this study of the South African material. These instances, with examples found in the literature, indicate that the subgeneric subdivisions of *Rubus* are artificial.

Three different methods were used to analyse the meiotic chromosome configurations. The genome relationship system of Alonso & Kimber (1981) and Kimber & Alonso (1981) and the modification of the binomial system of Jackson & Casey (1980) by Spies (1984) proved to be the most sensitive for distinguishing between allo-, segmental allo- and autopoloids.

UITTREKSEL

Die genus *Rubus* L. word in suidelike Afrika verteenwoordig deur die subgenera *Eubatus* Focke en *Idaeobatus* Focke. 'n Kombinasie van morfologiese data, data rakende die voortplantingsstelsel van sommige eksemplare en meiotiese chromosoomgedrag het aangetoon dat 'n basterkompleks in die oostelike Transvaal gevorm is na die verbastering van *R. cuneifolius* Bailey takson B (subgenus *Eubatus*) en *R. longepedunculatus* (C. E. Gust.) C. H. Stirton (subgenus *Idaeobatus*). Ander voorbeelde van intra- en intersubgeneriese verbastering is tydens hierdie studie in Suid-Afrika gevind en in samehang met verdere voorbeelde in die literatuur toon dit aan dat die onderverdeling van die genus *Rubus* in subgenera kunsmatig is.

Drie verskillende metodes is gebruik om die meiotiese chromosoomgedrag van die plante te vergelyk. Die genoom-verwantskapsstelsel van Alonso & Kimber (1981) en Kimber & Alonso (1981) en die modifikasies op die binomiale stelsel van Jackson & Casey (1980) deur Spies (1984) toon aan dat hierdie twee metodes die sensitiefste is om tussen allo-, segmentale allo- en outoploïede plante te onderskei.

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INTRODUCTION

The genus *Rubus* is somewhat enigmatic in South Africa. It forms part of our indigenous flora but naturalized species also occur. Most taxa are considered weedy and yet they are included in a breeding programme to

improve their agricultural production. The genus also contains agamic species as well as sexual species. In short, it is a taxonomist's nightmare.

The genus *Rubus* comprises 12 subgenera of which two are represented in South Africa: *Eubatus* Focke and *Idaeobatus* Focke. In South Africa the subgenus *Eubatus*, or true brambles or blackberries, includes only exotics, whereas the subgenus *Idaeobatus*, or raspberries, contains a few exotics and a number of indigenous species (Spies & Du Plessis 1985).

It has been proposed (Stirton 1981a & b; Spies & Du Plessis 1985) that the problems with *Rubus* taxonomy in South Africa are caused by the occurrence of apomixis, hybridization among indigenous species and between indigenous and exotic species, the variation produced by a breeding program with subsequent escape from cultivation and inadequately collected herbarium material.

Each paper in this series has dealt with a different aspect of the cytogenetics of *Rubus* in South Africa. The aim of this paper is to determine whether natural hybridization occurs in the South African *Rubus* complex and whether this hybridization, if it does occur, is restricted to intrasubgeneric taxa.

MATERIALS AND METHODS

The following specimens were collected in the veld, transplanted in the Pretoria National Botanical Garden

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** The Herbarium, Royal Botanical Gardens, Kew, Richmond, Surrey, TW9 3AE, United Kingdom.

and subsequently examined for this study [All the herbarium specimens are housed in the Pretoria National Herbarium (PRE)]:

R. cuneifolius Pursh taxon A*

NATAL.—2929 (Underberg): 14 km from Swartberg to Underberg (—CD), *Stirton* 8154. 2930 (Pietermaritzburg): 3 km from Midmar Dam to Lions River (—CB), *Henderson & Gaum* 93; 5 km from Pietermaritzburg to Mooi River (—CB), *Liengme s.n.*; Highlands Farm (—CD), *Beard* 720. 3029 (Kokstad): 40 km from Underberg to Swartberg (—BA), *Stirton* 8157; 11 km from Harding to Weza (—DB), *Stirton* 8102.

R. cuneifolius Pursh taxon B*

TRANSVAAL.—2329 (Pietersburg): 3 km from Haenertsburg to Boyne (—CC), *Stirton* 8033. 2330 (Tzaneen): Modderfontein (—CC), *Stirton* 8013. 2430 (Pilgrim's Rest): 1 km from Graskop to Sabie (—DD), *Stirton* 9800, 9859, 9861, 9868, *Henderson & Gaum* 18. 2530 (Lydenburg): 5 km from Lydenburg to Sabie (—AB), *Henderson & Gaum* 37; Dullstroom (—AC), *Stirton* 7255. 2628 (Johannesburg): Heidelbergkloof (—CA), *Bredenkamp* 123.

R. longepedicellatus (C. E. Gust.) C. H. Stirton

TRANSVAAL.—2329 (Pietersburg): 10 km from Tzaneen to Haenertsburg (—CC), *Stirton* 5755; near Pietersburg (—CD), *McCullum* 13. 2330 (Tzaneen): Pietersburg District (—CC), *McCullum* 887. 2430 (Pilgrim's Rest): Pilgrim's Rest (—DB), *Killick & Strey* 2420; Mariepskop (—DB), *Van der Schijff* 4562; Bourke's Luck (—DB), *Viljoen* 27; 1 km from Graskop to Sabie (—DD), *Henderson & Gaum* 22, *Stirton* 9862. 2530 (Lydenburg): 5 km from Lydenburg to Sabie (—AB), *Henderson & Gaum* 36; Brooklands (—BA), *Henderson & Gaum* 14; Nelspruit (—BD), *Mogg* (PRE 55710). 2531 (Komatipoort): Kruger National Park (—AB), *Van der Schijff* 1228.

NATAL.—3029 (Kokstad): Ngeli Forest (—DA), *Stirton* 8135.

R. × proteus sp. ined.

TRANSVAAL.—2329 (Pietersburg): 10 km from Tzaneen to Haenertsburg (—CC), *Stirton* 5756, 5783. 2430 (Pilgrim's Rest): Spekboom River, Burgersfort (—CB), *Henderson* 319; Bourke's Luck (—DB), *Henderson & Gaum* 27, 28, 29, 31, 32; Mac-Mac Waterfalls (—DD), *Henderson & Gaum* 20; 6 km from Pilgrim's Rest to Lydenburg (—DD), *Henderson & Gaum* 33; 1 km from Graskop to Sabie (—DD), *Stirton* 9797, 9798, 9799, 9801, 9855, 9860, 9862, 9863, 9864, 9865, 9866, 9867, 9869. 2530 (Lydenburg): 3 km from Brooklands to Hendriksdal (—BA), *Henderson & Gaum* 12; 33 km from Nelspruit to Sabie (—BD), *Henderson & Gaum* 11.

R. rigidus × *R. cuneifolius* taxon A

NATAL.—2929 (Underberg): 25 km from Himeville to Boesmansnek (—DC), *Henderson & Gaum* 50, 51.

This cytotaxonomic study concentrated upon a possible hybrid swarm in the area between Graskop and Sabie in the eastern Transvaal Lowveld (2430DD) (*Stirton* 1984). The cytogenetical methods and results were reported by Spies & Du Plessis (1985 & 1986) and Spies, Du Plessis & Liebenberg (1985). These investigations included meiotic analyses of aceto-carmine anther squashes and embryo sac studies.

In order to compare morphological characters of the plants, the following 18 characters were studied (Table

1): 1, inflorescence length; 2, flowers single or double; 3, flower colour; 4, petal length; 5, width of petal; 6, form of sepal apex; 7, ratio between length of petal and sepal; 8, rachis length; 9, length of petiole; 10, thorns straight or recurved; 11, leaf surface; 12, form of leaf apex; 13, leaf margin; 14, form of stipule; 15, number of leaflets per leaf in the florican; 16, primocane leaves; 17, terminal leaf length and 18, form of base of terminal leaflet.

In an attempt to determine cytogenetically whether hybridization has occurred, three different methods were used to compare the observed chromosome configurations of polyploids with the expected values for autopolyploids. These methods included the genomic relationship system developed by Kimber and others (Kimber & Hulse 1978; Driscoll 1979; Driscoll, Bielg & Darvey 1979; Alonso & Kimber 1981; Espinasse & Kimber 1981; Kimber & Alonso 1981; Kimber, Alonso & Sallee 1981; Alonso & Kimber 1984), the binomial system developed by Jackson *et al.* (Jackson & Casey 1980 & 1982; Jackson & Hauber 1982) and the modification of this binomial system by Spies (1984). Computer programmes were used to calculate these values. The model with the smallest average sum of squares between the expected and observed frequencies, was considered as being the most appropriate model.

RESULTS

Morphology

The two probable species participating in the formation of the apparent hybrid swarm were identified as *R. longepedicellatus* (C. E. Gust.) C. H. Stirton of the subgenus *Idaeobatus* Focke and *R. cuneifolius* Pursh taxon B belonging to the subgenus *Eubatus* Focke. It was assumed that these species formed morphologically distinct hybrids, referred to here collectively as, *R. × proteus* C. H. Stirton. The morphology of the different plants is summarized in Table 1.

In order to determine whether the *R. × proteus* specimens are intermediate between the putative parental species or fall within the normal infraspecific variation of these species, all *R. cuneifolius* B and *R. longepedicellatus* specimens in the National Herbarium (PRE) were scored for the selected characters listed in Materials and methods. These results are also summarized in Table 1 and clearly indicate that both these species are morphologically variable.

Nevertheless, several distinct morphological differences between *R. longepedicellatus* and *R. cuneifolius* B were observed. For example, the average petal length in *R. cuneifolius* B was 17,1 mm, compared to the average of 6,4 mm for *R. longepedicellatus*. *R. cuneifolius* B is separated from *R. longepedicellatus* mainly on flower colour, petal and rachis lengths, ratio between the lengths of the petal and the sepal and whether the primocane leaves are pinnate or pinnate/palmate. Characters that did not contribute to the separation of these species were double or single flowers, petiole length, straight or recurved thorns, con- or discolorous leaf surfaces, number of leaflets per leaf in the florican and the terminal leaf length. It was therefore decided to use only those characters which contributed to the separation of the species, to determine a hybrid index (Figure 1) according to the method developed by Anderson (1949).

* For some time we have been aware that *R. cuneifolius* Pursh might comprise more than one taxon. The discovery of hybrid swarms in the eastern Transvaal confirmed this. We have been unable to clarify the identity of the Transvaal forms of *R. cuneifolius*, except that they may be conspecific with *R. pascuus* Bailey. However, the cytogenetic information would argue against recognizing *R. pascuus* at the species level. We feel, therefore, that until its status is resolved, we will refer to it as *R. cuneifolius* Pursh taxon B, whereas the Natal form (or typical form) of *R. cuneifolius* will be referred to as taxon A.

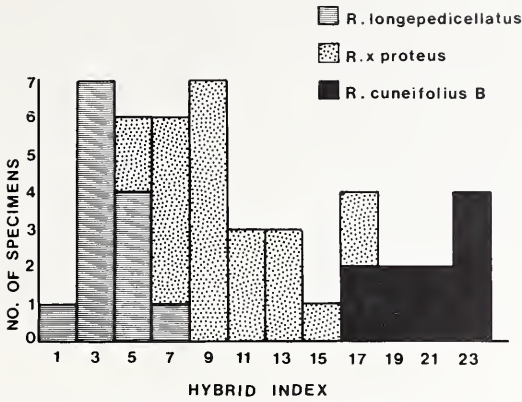


FIGURE 1.—Histogram of hybrid indices for specimens of *R. longepedunculatus* (area with horizontal lines), *R. cuneifolius* B (solid area) and *R. x proteus* (dotted area).

A scatter diagram (Figure 2) was constructed using the rachis and petal lengths on the X- and Y-axes respectively. Other morphological characters used in the scatter diagram were flower colour, the ratio between the

lengths of the petals and sepals and whether the primocane leaves were pinnate or pinnate/palmate.

Reproductive system

The presence of both reduced (sexual) and unreduced (aposporic) embryo sacs was described in the triploid *R. cuneifolius* B specimens, *Henderson & Gaum* 18 and *Stirton* 9800 (Spies & Du Plessis 1986). However, all the reduced embryo sacs were observed to degenerate at maturity. The one tetraploid specimen, *Stirton* 9861, was 100 % sexual, whereas the other one, *Stirton* 9868, was only 35 % sexual. In addition to this sexual and asexual reproduction through seeds, all specimens reproduced vegetatively through stemtip-rooting.

In contrast to the apospory described in the *R. cuneifolius* B specimens, no apospory was observed at any ploidy level in the *R. longepedunculatus* sample studied, except that in the pentaploid *R. longepedunculatus* specimen, *Henderson & Gaum* 36, all the reduced embryo sacs degenerated at maturity and the plant was, therefore, sterile (Spies & Du Plessis 1986). Vegetative reproduction occurs through rhizomes.

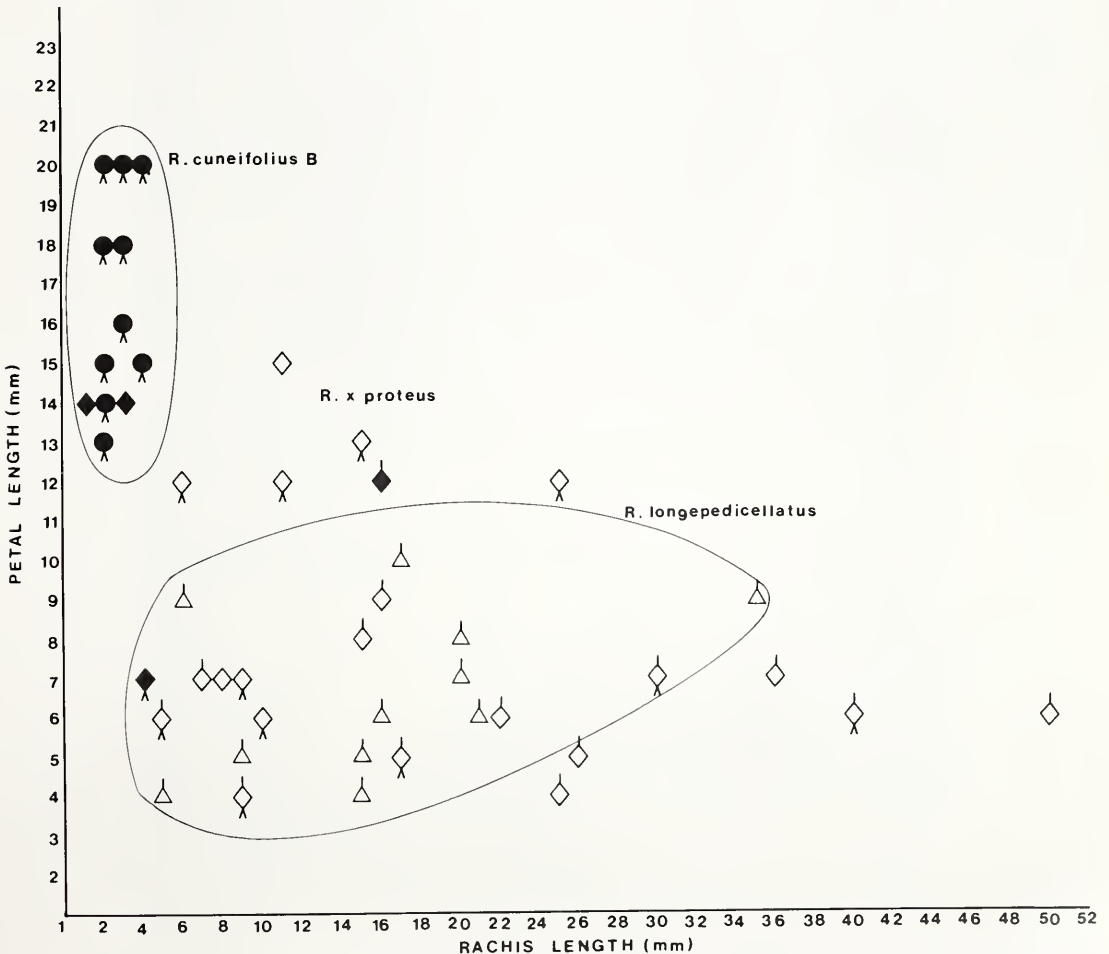


FIGURE 2.—Scatter diagram of *R. longepedunculatus* $\triangle$, *R. cuneifolius* B $\bullet$ and *R. x proteus* $\blacklozenge$ specimens. The occurrence of white flowers in a specimen is indicated by a solid character in contrast to the line character used for pink flowers. Specimens in which the petal length exceeds the sepal length are indicated by a Δ -sign under the character and pinnate leaves are indicated by a $\wedge$ -sign above the character.

TABLE 1.—List of morphological character values allocated to different *Rubus* specimens

Morphological character	Character value for different specimens																												
	<i>R. cuneifolius</i> A														<i>R. longepedunculatus</i>														
	<i>Beard 720</i>	<i>Henderson & Gaum 93</i>	<i>Liengme s.n.</i>	<i>Stirton 8102</i>	<i>Stirton 8154</i>	<i>Stirton 8157</i>	<i>Bredenkamp 123</i>	<i>Henderson & Gaum 18</i>	<i>Henderson & Gaum 37</i>	<i>Stirton 7255</i>	<i>Stirton 8013</i>	<i>Stirton 8033</i>	<i>Stirton 9800</i>	<i>Stirton 9859</i>	<i>Stirton 9861</i>	<i>Stirton 9868</i>	<i>Henderson & Gaum 14</i>	<i>Henderson & Gaum 22</i>	<i>Henderson & Gaum 36</i>	<i>Killick & Strey 2420</i>	<i>McCullum 13</i>	<i>McCullum 887</i>	<i>Mogg s.n.</i>	<i>Stirton 5755</i>	<i>Stirton 8135</i>	<i>Van der Schijff 1228</i>	<i>Van der Schijff 4562</i>	<i>Viljoen 27</i>	
1. Inflorescence length	IN	IN	IN	IS	IS	IS	IN	IS	IS	IN	IN	IS	IN	IN	IN	IS	IS	IN	IL	IN	IL	IL	IL	IL	IL	IL	IL	IL	IL
2. Flowers	FS	FS	FS	FS	FS	FS	FS	FD	FD	FS	FD	FS	FS	FS	FD	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS
3. Flower colour	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW	PI	PI	PI	PI	PI	PI	PI	PI	PI	PI	PI	PI
4. Petal length (mm)	16	15	17	17	18	22	16	20	18	15	13	20	14	18	20	15	7	5	9	8	5	6	4	4	10	5	4	6	6
5. Petal width (mm)	5	8	16	11	14	11	11	10	10	7	9	15	11	10	11	10	10	6	3	6	4	4	4	3	4	6	4	3	3
6. Form of sepal apex	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
7. Ratio between length of petal and sepal	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS
8. Rachis length (mm)	4	3	3	3	3	4	3	4	3	2	2	3	2	2	3	4	20	26	35	20	15	16	15	5	17	9	25	21	
9. Petiole length (mm)	30	12	15	15	16	20	25	20	45	10	15	12	8	8	22	20	30	30	45	22	30	30	20	15	35	20	35	50	
10. Thorns	—	TB	TR	TR	TR	TR	TR	TR	TR	TS	TR	—	TR	—	TR	TR	TR	TR	TS	TR	TR	TR	TR	TR	TS	TB	TB	TR	TR
11. Leaf surface	CI	CC	CI	CC	CD	CI	CC	CC	CC	CI	CC	CD	CC	CC	CC	CC	CC	CC	CC	CC	CD	CD	CD	CD	CD	CD	CD	CD	
12. Form of leaf apex	AC	AM	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AC	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
13. Leaf margin	LP	LB	LB	LB	LB	LP	LP	LB	LB	LB	LB	LP	LB	LB	LB	LB	LB	LS	LP	LS	LS	LS	LS	LS	LB	LB	LS	LS	LS
14. Form of stipule	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN
15. No. leaflets/leaf in florifere	3	3	3	3	1-3	1-3	3	1-3	3	1-3	1-3	1-3	3	3	1-3	3	1-3	5-7	3	3	3	1-3	3	3	3	3-5	3	1-3	3
16. Primocane leaves	—	PB	PB	—	—	PB	—	PB	PB	PB	—	—	PB	PB	—	—	—	PB	PA	—	—	—	—	—	PA	PA	—	—	—
17. Terminal leaf length (mm)	60	50	55	33	40	40	70	80	55	30	50	40	45	60	80	70	70	55	90	45	50	66	65	30	70	40	75	53	
18. Form of base of terminal leaflet	BO	BT-BN	BN	BN	BN	BN	BO	BN	BN	BC	BN	BT	BO	BN	BN	BN	BN	BO	BT	BC	BO	BO	BO	BO	BT	BC	BT	BO	BC

AC, acute; AM, acuminate; BC, cordate; BN, cuneate; BO, obtuse; BT, truncate; CC, concolourous; CD, discolourous; CI, leaf slightly discolourous; FD, flower double; FS, flower single; IL, long; IN, intermediate; IS, short; LD, double serrate; LR, serrate; LS, serrulate; PA, pinnate; PB, pinnate/palmate; PE, petal = sepal; PI, pink; PL, petal > sepal; PP, pale pink; PS, petal < sepal; PW, white; SF, flabellate; SL, lanceolate, triangular or falcate; SN, needle, linear or filiform; TB, some thorns recurved and others straight; TR, recurved; TS, straight.

TABLE 1.—List of morphological character values allocated to different *Rubus* specimens (continued)

Morphological character	Character value for different specimens																	
	<i>R. X proteus</i>																	
	Henderson 319																	
1. Inflorescence length	IN	IL	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS
2. Flowers	PI	PP	PI	PP	PI	PP	PI	PP	PI	PP	PI	PP	PI	PP	PI	PP	PI	PP
3. Flower colour	6	5	7	9	6	4	6	4	6	4	6	4	6	4	6	4	6	4
4. Petal length (mm)	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6
5. Petal width (mm)	AC	AM	AC	AM	AC	AM	AC	AM	AC	AM	AC	AM	AC	AM	AC	AM	AC	AM
6. Form of sepal apex	PL	PE	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS	PS
7. Ratio between length of petal and sepal	10	17	30	16	22	40	36	9	50	5	7	4	25	2	7	15	11	6
8. Rachis length (mm)	20	32	45	15	35	40	30	19	30	15	16	10	33	15	30	25	25	21
9. Petiole length (mm)	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
10. Thorns	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC	CC
11. Leaf surface	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
12. Form of leaf apex	LP	LS	LB	LB	LS	LB	LS	LB	LS	LB	LS	LB	LS	LB	LS	LB	LS	LB
13. Leaf margin	14.	Form of stipule	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN	SN
14. Form of stipule	1-3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15. No. leaflets/leaf in floricate	PB	PB	PB	PA	PB	PB	PB	PB	PB	PB	PA	PA	PA	PA	PA	PA	PA	PA
16. Primocane leaves	75	80	110	110	84	95	46	65	50	40	30	85	50	50	45	65	55	110
17. Terminal leaf length (mm)	BT	BN	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO
18. Form of base of terminal leaflet																		
	Henderson 5756																	
	Henderson 5783																	
	Henderson 9797																	
	Henderson 9798																	
	Henderson 9799																	
	Henderson 9801																	
	Henderson 9855																	
	Henderson 9860																	
	Henderson 9862																	
	Henderson 9863																	
	Henderson 9864																	
	Henderson 9866																	
	Henderson 9867																	
	Henderson 9869																	

AC, acute; AM, acuminate; BC, cordate; BN, cuneate; BO, obtuse; BT, truncate; CC, concolourous; CD, discolourous; CI, leaf slightly discolourous; FD, flower double; FS, flower single; IL, long; IN, intermediate; IS, short; LD, double serrate; LR, serrate; LS, serrulate; PA, pinnate; PB, pinnate/palmate; PE, petal = sepal; PI, pink; PL, petal > sepal; PP, pale pink; PS, petal < sepal; PW, white; SF, flabellate; SL, lanceolate, triangular or falcate; SN, needle, linear or filiform; TB, some thorns recurved and others straight; TR, recurved; TS, straight.

TABLE 2.—Average chiasma frequencies and average percentage of chromosome associations per polyploid level in the parental *Rubus* species and their putative hybrid

		<i>R. cuneifolius</i> B.		<i>R. longepedicellatus</i>				<i>R. × proteus</i>				
Somatic chromosome number		21	28	14	28	35	14	21	28*	28	35	42
Chiasma frequency		0,83	1,05	1,12	1,08	0,99	1,1	0,88	0,45	1,12	0,98	1,21
Chromosome Associations	I	30,98	5,30	2,14	1,34	14,90	—	29,76	55,40	1,50	13,79	4,40
	II	58,45	80,47	97,90	97,92	62,60	100	56,67	44,60	88,30	81,28	68,60
	III	10,72	5,09	—	—	14,60	—	13,57	—	4,03	3,22	14,60
	IV	—	9,14	—	0,70	8,00	—	—	—	6,17	1,72	12,40

* These frequencies are representative of *Stirton* 9798 and are not included in the averages because this specimen deviates substantially from the other specimens.

In the putative hybrid, *R. × proteus*, a mixture of reproductive systems seems to operate in the specimens. Only reduced embryo sacs were observed in the diploid (*Henderson & Gaum* 28) and one tetraploid specimen (*Henderson & Gaum* 27), whereas a mixture of reduced and aposporic embryo sacs was observed in the remaining specimens (*Henderson & Gaum* 20 and 31 and *Stirton* 8135, 9798, 9865, 9866 and 9869). Vegetative reproduction through stemtip-rooting and/or rhizomes was observed in the specimens studied.

Chromosome behaviour

Both putative parental species contain specimens on different polyploid levels. *R. cuneifolius* B has somatic chromosome numbers of 21 and 28 and *R. longepedicellatus* 14, 28 and 35, whereas their presumed hybrid, *R. × proteus*, has somatic chromosome numbers of 14, 21, 28, 35, 42, 49 and 56 (Spies & Du Plessis 1985; Spies *et al.* 1985).

The meiotic chromosome behaviour observed in *R. cuneifolius* B differs in some respects from that of the comparable ploidy level of *R. longepedicellatus* (Spies *et al.* 1985). The diploid *R. longepedicellatus* (*Henderson & Gaum* 22) specimen has a chiasma frequency of 1,12 per bivalent and that of the putative hybrid diploid specimen is similar, namely 1,1 (Table 2). Both diploid specimens usually formed bivalents, with the exception of two univalents in one *R. longepedicellatus* cell. The meiotic chromosome configurations in the triploid *R. cuneifolius* B and *R. × proteus* specimens were very similar (Table 2). No triploid *R. longepedicellatus* specimen has yet been found.

The method described by Spies (1984) for analysing the meiotic configurations in the pollen mother cells, indicates that the tetraploid *R. cuneifolius* B specimen is a segmental allopolyploid tending towards autopolyploidy, whereas the tetraploid *R. longepedicellatus* specimen is a segmental allopolyploid tending strongly towards autopolyploidy. Some of the tetraploid *R. × proteus* specimens appear to be segmental allopolyploids tending towards autopolyploidy (*Henderson & Gaum* 27 & 32), whereas one is probably an allopolyploid (*Stirton* 9798). The tetraploid *R. rigidus* × *R. cuneifolius* A specimen (*Henderson & Gaum* 51) seems to be a segmental allopolyploid tending towards autopolyploidy.

In a tetraploid *R. × proteus* specimen, *Stirton* 9798, asynapsis occurred in many pollen mother cells. In this specimen only 44,6 % bivalents were formed, whereas the remaining chromosomes were univalents (Table 2). The pentaploid *R. longepedicellatus* specimen tended to form less bivalents than the *R. × proteus* specimen. No higher ploidy levels than pentaploid were found in the parental species and comparison with the hexaploid *R. × proteus* specimens was, therefore, not possible. However, a surprisingly high frequency of multivalents (14,05 %) was observed in the higher ploidy levels of *R. × proteus* (Table 2).

The genome analysis indicated that there is no difference between the 2:1 and 3:0 models of Alonso & Kimber (1981), because the *x*-values in the 2:1 model were 0,5 for each triploid specimen, indicating that the two more closely related genomes are also closely related to the third genome. The model with 0–2 chiasmata of Jackson & Casey (1982) produced the same expected values as those obtained by using Kimber's models (Table 3). In all the specimens studied the average sum of squares increased from the 0–2 chiasmata model of Jackson & Casey (1982) to the 0–4 chiasmata model, indicating that the specimens studied have two or less chiasmata per chromosome pair (Table 4).

The genome analysis further indicated that the 2:2 model of Kimber & Alonso (1981) shows the best correspondence with the observed frequencies of chromosome associations in all the tetraploid *R. cuneifolius* B, *R. longepedicellatus* and *R. × proteus* specimens studied (Table 5). In each case the value of *x* was 1, indicating that two genomes are much more closely related to one another than to one of the other two genomes. The only exceptions were *Henderson & Gaum* 93 (*R. cuneifolius* A) and *Stirton* 9798 (*R. × proteus*) in which the 3:1 model fitted with *x*-values respectively of 0,5 and 0,501, indicating that the three closely related genomes have also a great affinity for the other genome. In both these cases the average sum of squares of the expected and observed frequencies of the accepted model varied very little from that of the 4:0 models.

In contrast to this phenomenon the model described by Jackson & Casey (1982) indicates that all the specimens

TABLE 3.—Comparison between observed chromosome configurations and the expected chromosome configurations in triploids according to the methods described by Alonso & Kimber (1981), Jackson & Casey (1980, 1982) and Jackson & Hauber (1982). Only the model with the lowest average sum of squares is given in this table

		Chromosome configuration						
		I	IIC	IIR	III	SS	X	C
<i>R. cuneifolius</i> A (<i>Liengme s.n.</i>)	O	6,32	6,07	0,25	0,68	—	—	—
	2:1	8,13	3,44	0,75	1,5	2,78	0,57	0,50
	0-2	8,13	3,44	0,75	1,5	2,78	—	—
<i>R. cuneifolius</i> B (<i>Stirton 9800</i>)	O	6,40	5,80	0,31	0,80	—	—	—
	2:1	8,02	3,43	0,77	1,53	2,25	0,50	0,57
	0-2	8,02	3,43	0,77	1,53	2,25	—	—
<i>R. cuneifolius</i> B (<i>Henderson & Gaum 18</i>)	O	6,57	5,38	0,79	0,70	—	—	—
	2:1	7,61	3,37	0,83	1,66	1,51	0,50	0,60
	0-2	7,61	3,37	0,83	1,66	1,51	—	—
<i>R. × proteus</i> (<i>Stirton 9866</i>)	O	6,25	5,95	0	0,95	—	—	—
	2:1	8,23	3,45	0,73	1,47	2,75	0,50	0,56
	0-2	8,23	3,45	0,73	1,47	2,75	—	—

O = observed frequency; 2:1 = Kimber's model where 2 genomes are more closely related to one another than to the third genome; 0-2 = Jackson's model where 0 to 2 chiasmata per bivalent are formed; I = univalents; IIC = rod bivalent; IIR = ring bivalent; III = trivalent; SS = average sum of squares of differences between observed and expected frequencies; X = value indicating the relative distance between the two homologous genomes and the third genome according to Kimber's models; C = chiasma frequency per half bivalent.

TABLE 4.—Comparison between the average sum of squares between the observed and expected values for chromosome configuration in triploids for different numbers of chiasmata according to Jackson's model (Jackson & Casey 1980, 1982; Jackson & Hauber 1982)

Species	Voucher No.	No. of chiasmata		
		0-2	0-3	0-4
<i>R. cuneifolius</i> A	<i>Liengme s.n.</i>	2,78	5,64	11,66
<i>R. cuneifolius</i> B	<i>Stirton 9800</i>	2,25	5,10	11,28
<i>R. cuneifolius</i> B	<i>Henderson & Gaum 18</i>	1,51	5,54	12,06
<i>R. × proteus</i>	<i>Stirton 9866</i>	2,75	5,00	10,59

studied are autotetraploids with 0-2 chiasmata per chromosome pair and with partly random chromosome associations. The model of Spies (1984) indicates that all the specimens are segmental allopolyploids but they vary from almost autopolyploid (*Henderson & Gaum 27, 51, 93* and *Stirton 9868*) to almost allopolyploid (*Henderson & Gaum 14, 32, Stirton 9798, 9861 & 9862*).

DISCUSSION

Morphology

Different methods can be used to ascertain whether a given specimen represents a true species or a hybrid. During this study several of these methods were used to determine the degree of hybridization in the genus *Rubus*. The first method used was based on morphological characters and in this process a hybrid index was determined and a scatter diagram constructed.

A study of morphological characters revealed that *R. cuneifolius* B has a short to medium length inflorescence (Table 1:1) with white flowers, whereas *R. longepedunculatus* has a medium to long inflorescence with pink flowers (2 & 3). *R. × proteus* has a short to long inflorescence with pink, pale pink or white flowers. The petal length (4) varied from 13 to 20 mm in *R.*

cuneifolius B, from 4 to 10 mm in *R. longepedunculatus* and from 4 to 15 mm in *R. × proteus*. The petal width (5) varies from 7 to 15 mm in *R. cuneifolius* B, from 3 to 6 mm in *R. longepedunculatus* and from 3 to 11 mm in *R. × proteus*. The same intermediate arrangement position is observed when the ratio between the lengths of the petals and sepals (7) is compared; in *R. cuneifolius* B the petal is always longer than the sepal, whereas in *R. longepedunculatus* the petal is as long or shorter than the sepal and *R. × proteus* has the whole range of ratios. *R. cuneifolius* B, has acute petal apices compared to the acuminate apices with an occasional acute apex in *R. longepedunculatus* and both acute and acuminate apices found in *R. × proteus*. The leaf apex (12) is always acute in *R. cuneifolius* B and the leaf margin (13) is usually serrate with a double serrate margin in exceptional cases. *R. longepedunculatus* and *R. × proteus* have acute or acuminate leaf apices and serrulate, double serrate or serrate leaf margins. The stipules (14) vary from lanceolate/triangular/falcate to flabellate in *R. cuneifolius* B, from needle/linear/filiform to occasionally lanceolate/triangular/falcate in *R. longepedunculatus*, with all these different shapes being represented in *R. × proteus*. In contrast to the pinnate/palmate leaves on the floricanes of *R. cuneifolius* B, *R. longepedunculatus* has pinnate leaves and both forms occur in *R. × proteus*. These morphological data indicate that *R. cuneifolius* B and *R. longepedunculatus* are morphologically separate species, and the intermediate nature of the *R. × proteus* specimens suggests a hybrid origin.

The hybrid index diagram (Figure 1) indicates that only one specimen had all the characters associated with *R. longepedunculatus*, whereas four specimens had all the characters associated with *R. cuneifolius* B. The hybrid index also indicates that *R. longepedunculatus* and *R. cuneifolius* B are clearly separated morphologically. However, a continuous bridge of morphological characters spans the gap between them in the form of the very variable hybrid species, *R. × proteus* (Figures 1, 2, 3 &

TABLE 5.—Comparison between observed chromosome configurations and the expected chromosome configurations in tetraploids according to the methods described by Kimber & Alonso (1981), Jackson & Casey (1980,1982) and Jackson & Hauber (1982). Only the two models with the lowest average sum of squares of each method are shown in the table

		Chromosome configuration								
		I	IIC	IIR	III	IVC	IVR	SS	X	C
<i>R. affinis</i> (Stirton 5746)	O	0,21	9,42	1,29	0,21	0,80	0,63	—	—	—
	4:0	4,49	3,15	1,87	1,33	1,69	0	10,06	—	0,62
	3:1	4,50	3,05	1,78	1,33	1,69	0,69	10,22	0,50	0,62
	0-2	3,54	4,39	1,53	1,04	1,69	0,69	6,31	—	—
	0-2R	4,06	3,88	1,79	1,04	1,69	0,69	7,88	—	—
<i>R. cuneifolius</i> A (Henderson & Gaum 93)	O	2,30	6,76	0,74	1,30	0,75	0,95	—	—	—
	4:0	4,85	3,26	1,78	1,38	1,63	0	3,59	—	0,60
	3:1	4,87	3,16	1,69	1,37	1,63	0,62	3,55	0,50	0,60
	0-2	3,87	4,54	1,43	1,07	1,63	0,62	1,47	—	—
	0-2R	4,41	4,01	1,70	1,07	1,63	0,62	2,31	—	—
<i>R. cuneifolius</i> B (Stirton 9861)	O	1,25	11,88	0,17	0,35	0,40	—	—	—	—
	4:0	7,37	3,82	1,28	1,50	1,19	0,62	17,66	—	0,50
	2:2	6,88	7,00	3,56	0	0	0	14,96	1,00	0,50
	0-2	6,30	5,23	0,90	1,17	1,19	0,30	11,93	—	—
	0-2R	6,88	4,65	1,19	1,07	1,19	0,30	14,41	—	—
<i>R. cuneifolius</i> B (Stirton 9868)	O	1,72	9,92	0,56	0,60	0,62	0,26	—	—	—
	4:0	6,39	3,63	1,45	1,48	1,36	0,30	10,57	—	0,54
	2:2	5,91	6,95	4,09	0	0	0	9,90	1,00	0,54
	0-2	5,33	5,02	1,08	1,15	1,36	0,40	6,36	—	—
	0-2R	5,91	4,45	1,36	1,15	1,36	0,40	8,17	—	—
<i>R. flagellaris</i> (Henderson & Gaum 2)	O	0,10	12,85	1,10	0	0	0	—	—	—
	4:0	6,47	3,65	1,44	1,48	1,34	0,40	21,58	—	0,54
	2:2	5,99	6,96	4,04	0	0	0	17,33	1,00	0,54
	0-2	5,41	5,04	1,06	1,15	1,34	0,39	15,41	—	—
	0-2R	5,99	4,47	1,35	1,15	1,34	0,39	18,05	—	—
<i>R. apetalus</i> (G. Hemm s.n.)	O	0	7,87	3,25	0	0,46	0,99	—	—	—
	4:0	2,78	2,54	2,38	1,04	1,93	0,39	6,75	—	0,70
	2:1:1	3,19	2,76	4,14	0,85	1,37	0,69	6,46	0,86	0,70
	0-2	2,05	3,50	2,11	0,81	1,93	1,15	4,57	—	—
	0-2R	2,45	3,10	2,31	0,81	1,93	1,15	5,42	—	—
<i>R. apetalus</i> (Henderson & Gaum 6)	O	0,35	10,93	1,27	0,35	0,33	0,22	—	—	—
	4:0	5,57	3,45	1,62	1,44	1,50	1,15	14,47	—	0,57
	2:2	5,11	6,85	4,59	0	0	0	12,13	1,00	0,57
	0-2	4,55	4,79	1,25	1,12	1,50	0,50	9,56	—	—
	0-2R	5,11	4,23	1,53	1,12	1,50	0,50	11,60	—	—
<i>R. apetalus</i> (Wells 5000)	O	0	13,15	0,85	0	0	0	—	—	—
	4:0	6,66	3,69	1,40	1,49	1,31	0,50	23,06	—	0,53
	2:2	6,18	6,97	3,94	0	0	0	18,63	1,00	0,53
	0-2	5,60	5,09	1,02	1,16	1,31	0,37	16,59	—	—
	0-2R	6,18	4,51	1,31	1,16	1,31	0,37	19,37	—	—
<i>R. longepedicellatus</i> (Henderson & Gaum 14)	O	0,60	12,85	0,65	0	0,10	0	—	—	—
	4:0	7,05	3,76	1,33	1,50	1,24	0	21,35	—	0,52
	2:2	6,56	6,99	3,73	0	0	0	17,55	1,00	0,52
	0-2	5,98	5,17	0,95	1,16	1,24	0,33	15,13	—	—
	0-2R	6,56	4,59	1,24	1,16	1,24	0,33	17,81	—	—
<i>R. longepedicellatus</i> (Stirton 9862)	O	0,16	12,28	1,64	0	0	0	—	—	—
	4:0	6,00	3,55	1,53	1,46	1,43	0,33	19,10	—	0,56
	2:2	5,53	6,91	4,32	0	0	0	15,10	1,00	0,56
	0-2	4,96	4,92	1,16	1,14	1,42	0,45	13,49	—	—
	0-2R	5,53	4,35	1,44	1,14	1,42	0,45	15,87	—	—

O = observed frequency; 4:0 = Kimber's model where all 4 genomes are homologous; 3:1 = Kimber's model where 3 genomes are more closely related to one another than to the fourth genome; 2:2 = Kimber's model where 2 genomes are more closely related to one another than to any of the other two genomes, which are also related to one another; 2:1:1 = Kimber's model where 2 genomes are more closely related to one another than to the third genome and the third and fourth genomes are not closely related; 0-2 = Jackson's model where 0 to 2 chiasmata per bivalent are partially randomly formed; 0-2R = Jackson's model where 0 to 2 chiasmata per bivalent are randomly formed; I = univalents; IIC = rod bivalent; IIR = ring bivalent; III = trivalent; IVC = rod quadrivalents; IVR = ring quadrivalents; SS = average sum of squares of differences between observed and expected frequencies; X = value indicating the relative distance between the different genomes according to Kimber's models; C = chiasma frequency per half bivalent.

TABLE 5.—Comparison between observed chromosome configurations and the expected chromosome configurations in tetraploids according to the methods described by Kimber & Alonso (1981), Jackson & Casey (1980, 1982) and Jackson & Hauber (1982). Only the two models with the lowest average sum of squares of each method are shown in the table (continued)

		Chromosome configuration								
		I	IIC	IIR	III	IVC	IVR	SS	X	C
<i>R. pinnatus</i> (Arnold 1335)	O	0	9,98	1,86	0	0,60	0,48	—	—	—
	4:0	4,42	3,13	1,89	1,33	1,70	0,45	11,57	—	0,62
	2:2	4,00	6,58	5,42	0	0	0	11,00	1,00	0,62
	0-2	3,48	4,37	1,55	1,03	1,70	0,70	7,67	—	—
	0-2R	4,00	3,85	1,81	1,03	1,70	0,70	9,31	—	—
<i>R. × proteus</i> (Stirton 9798)	O	15,50	6,25	0	0	0	0	—	—	—
	2:1:1	17,14	3,69	0,28	0,72	0,16	0,01	1,65	0,583	0,22
	3:1	17,14	3,72	0,26	0,72	0,16	0,01	1,61	0,501	0,22
	0-2	16,61	4,41	0,09	0,56	0,16	0,01	0,83	—	—
	0-2R	16,90	4,13	0,23	0,56	0,16	0,01	1,14	—	—
<i>R. × proteus</i> (Henderson & Gaum 27)	O	0,70	11,10	1	0,70	0,10	0,15	—	—	—
	4:0	6,15	3,58	1,50	1,47	1,40	0	14,79	—	0,55
	2:2	5,67	6,93	4,24	0	0	0	11,97	1,00	0,55
	0-2	5,10	4,96	1,13	1,14	1,40	0,43	9,84	—	—
	0-2R	5,67	4,39	1,41	1,14	1,40	0,43	11,98	—	—
<i>R. × proteus</i> (Henderson & Gaum 32)	O	0,45	12,15	1,40	0,15	0	0	—	—	—
	4:0	6,29	3,61	1,47	1,48	1,37	0,43	18,46	—	0,54
	2:2	5,81	6,94	4,15	0	0	0	14,63	1,00	0,54
	0-2	5,23	5,00	1,10	1,15	1,37	0,41	12,86	—	—
	0-2R	5,81	4,42	1,38	1,15	1,37	0,41	15,24	—	—
<i>R. × proteus</i> (Henderson & Gaum 51)	O	0,12	10,03	1,41	0,28	0,10	0,94	—	—	—
	4:0	4,38	3,12	1,90	1,32	1,71	0,41	11,69	—	0,62
	2:2	3,96	6,57	5,45	0	0	0	11,07	1,00	0,62
	0-2	3,45	4,35	1,56	1,03	1,71	0,71	7,75	—	—
	0-2R	3,96	3,84	1,82	1,03	1,71	0,71	9,41	—	—
<i>R. transvaliensis</i> <i>× R. longepedicellatus</i> (Henderson & Gaum 10)	O	0	13,05	0,95	0	0	0	—	—	—
	4:0	6,57	3,67	1,42	1,49	1,33	0,71	22,63	—	0,53
	2:2	6,09	6,97	3,99	0	0	0	18,20	1,00	0,53
	0-2	5,50	5,07	1,04	1,16	1,32	0,38	16,22	—	—
	0-2R	6,08	4,49	1,33	1,16	1,32	0,38	18,95	—	—
<i>Rubus</i> sp. (Henderson & Gaum 24)	O	2,24	7,47	0,52	0,65	1,45	0,50	—	—	—
	4:0	5,47	3,42	1,64	1,43	1,52	0,38	4,78	—	0,58
	3:1	5,48	3,33	1,56	1,43	1,52	0,52	4,89	0,50	0,58
	0-2	4,45	4,76	1,28	1,11	1,52	0,52	2,17	—	—
	0-2R	5,01	4,20	1,55	1,11	1,52	0,52	3,27	—	—

O = observed frequency; 4:0 = Kimber's model where all 4 genomes are homologous; 3:1 = Kimber's model where 3 genomes are more closely related to one another than to the fourth genome; 2:2 = Kimber's model where 2 genomes are more closely related to one another than to any of the other two genomes, which are also related to one another; 2:1:1 = Kimber's model where 2 genomes are more closely related to one another than to the third genome and the third and fourth genomes are not closely related; 0-2 = Jackson's model where 0 to 2 chiasmata per bivalent are partially randomly formed; 0-2R = Jackson's model where 0 to 2 chiasmata per bivalent are randomly formed; I = univalents; IIC = rod bivalent; IIR = ring bivalent; III = trivalent; IVC = rod quadrivalents; IVR = ring quadrivalents; SS = average sum of squares of differences between observed and expected frequencies; X = value indicating the relative distance between the different genomes according to Kimber's models; C = chiasma frequency per half bivalent.

4). It is also indicated that the hybrid species overlaps morphologically with both parental species. The five major characters described above (i.e. flower colour, petal and rachis lengths, ratio between length of petal and sepal and whether the primocane leaves are pinnate or pinnate/palmate) are, therefore, essential for distinguishing between the true species and the different hybrids.

The pictorialized scatter diagram (Figure 2) indicates that more hybrid specimens overlap with *R. longepedicellatus* than with *R. cuneifolius* B. *R. longepedicellatus* is completely surrounded by *R. × proteus* specimens in

this diagram. Distinguishing between them will, therefore, be more difficult than between *R. cuneifolius* B and *R. × proteus*.

It is evident from these two diagrams that *R. cuneifolius* B and *R. longepedicellatus* represent the two extremes of a very variable population of plants (Figure 3). It is further evident that *R. × proteus*, which constitutes the morphologically intermediate population (Figure 4), resulted from hybridization between *R. cuneifolius* B and *R. longepedicellatus* and subsequent backcrosses and intercrosses to produce a continuously variable hybrid swarm.

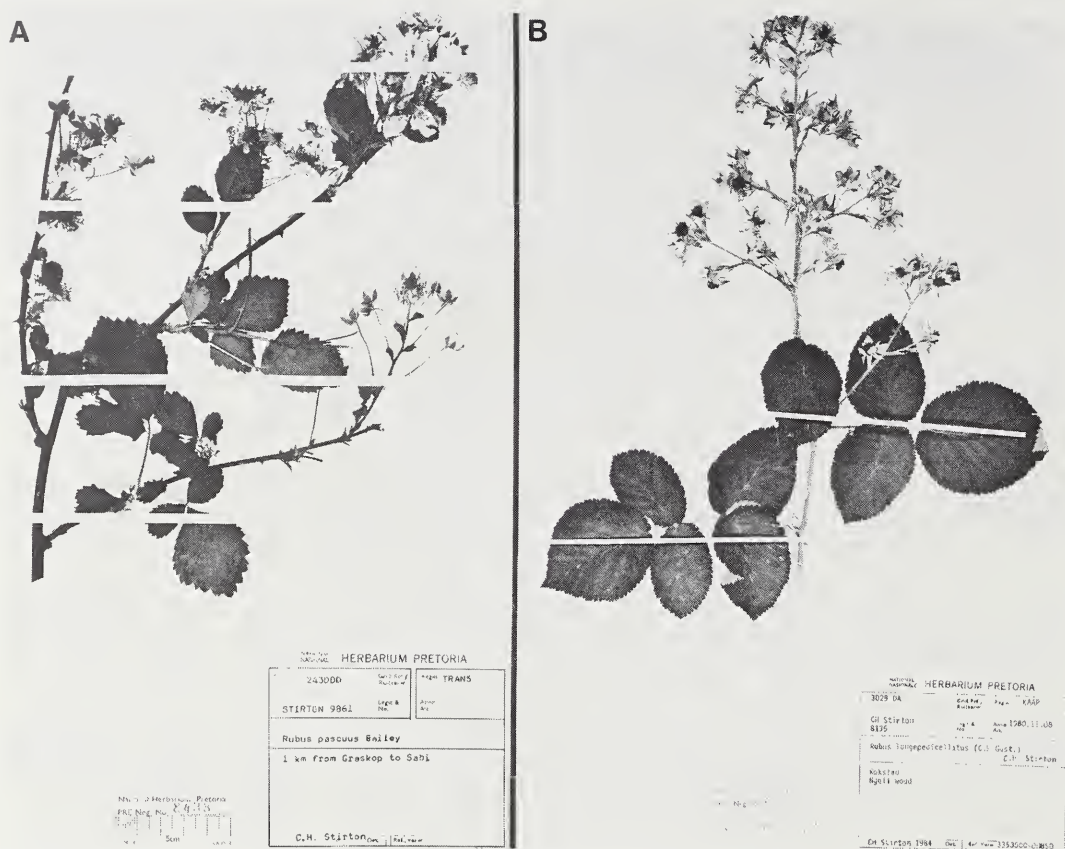


FIGURE 3.—Specimens of A, *Rubus cuneifolius* B (Stirton 9861); B, *R. longepedicellatus* (Stirton 8135).

The above hybridization hypothesis is also supported by the geographical distribution of the species concerned. *R. cuneifolius* B is restricted to the Transvaal, whereas *R. longepedicellatus* specimens were collected in the Transvaal and Natal, with the majority of them collected in the Transvaal. The low frequency of *R. × proteus* and *R. longepedicellatus* specimens from Natal in the collection may be attributed to an insufficient number of *Rubus* collections from Natal. The absence of *R. cuneifolius* B specimens from Natal in the National Herbarium may be due to inadequate collecting or to its non-occurrence in this province. If the latter is true, the paucity of *R. × proteus* specimens from Natal is explained. The specimen resembling *R. × proteus* (Henderson & Gaum 51) from Natal rather represents a hybrid between *R. cuneifolius* A and *R. rigidus* than *R. × proteus* itself. The morphological differences between *R. cuneifolius* B and *R. cuneifolius* A are very slight and hybrids between any one of these taxa and *R. longepedicellatus* will result in morphologically similar hybrids. The only differences observed between these taxa are small differences in the leaf texture and leaf margin, as well as the frequent occurrence of double flowers in *R. cuneifolius* B. No *R. cuneifolius* A specimen with double flowers was observed. Since all *R. × proteus* specimens have single flowers, it is possible that *R. cuneifolius* A and B are interchangeable as parents with *R. longepedicellatus*.

Reproductive system

The embryo sac study indicated that both putative parents produce reduced embryo sacs and may, therefore, participate in hybridization. It was further demonstrated that a number of hybrids also produced reduced embryo sacs and so backcrossing to either parent is also possible. In addition to reduced reproduction all hybrid specimens had the potential to reproduce asexually, either through agamospermy or vegetatively. This apomictic reproduction provides all plants with the potential to reproduce even when meiotic chromosome pairing fails after interspecific hybridization. Although the embryo sac study cannot prove the occurrence of hybridization, it indicates that hybridization is possible and that interspecific hybrids may either reproduce sexually or perpetuate themselves apomictically.

Chromosome behaviour

The somatic chromosome numbers of 21 and 28 in *R. cuneifolius* B and 14, 28 and 35 in *R. longepedicellatus* (Table 2) seem to contradict hybridization because, although a diploid hybrid specimen exists, no diploid *R. cuneifolius* B specimen has yet been observed. However, the occurrence of triploid *R. cuneifolius* B specimens with meiotic chromosome behaviour resembling autopolyploids, suggests that these triploids are formed by pollination of autotetraploids by diploids, both containing



FIGURE 4.—Specimens of *Rubus x proteus*. A, Stirton 9799; B, Stirton 9869; C, Stirton 5783; D, Henderson & Gaum 20.

similar genomes. Therefore, it is suggested that diploid *R. cuneifolius* B specimens do exist and that they could have hybridized with diploid *R. longepedicellatus* specimens to form diploid hybrids. The occurrence of a diploid hybrid *R. × proteus* specimen (Henderson & Gaum 28), with normal chromosome pairing during meiosis (Table 2), indicates that the genomic differences between the parental species are insignificant. The two diploid parents of *R. × proteus* probably differ only in a few gene loci and as such must be considered varieties of the same species.

This homology between the genomes of *R. cuneifolius* B and *R. longepedicellatus* is also manifested at higher ploidy levels. However, differences in the meiotic chromosome behaviour of polyploid *R. × proteus* specimens was observed. These differences include a variation in chromosome pairing from the multivalent formation expected in autopolyploids to that expected in allopolyploids. These differences can be attributed to either pre- or post-hybridization chromosomal evolution.

Pre-hybridization chromosomal evolution would suggest that structural chromosome differences were present in some plants of the parental populations. Hybridization between such plants followed by polyploidization would give rise to segmental allopolyploids with meiotic chromosome pairing resembling that of allopolyploids. The normal meiosis found in a diploid hybrid specimen (Henderson & Gaum 28), indicates that only very small structural differences exist at the diploid level between the genomes of at least some plants of the parental taxa.

The results of Spies *et al.* (1985) indicate that the polyploids of *R. cuneifolius* B may have had an autopolyploid origin in contrast to the presumed segmental allopolyploid origin of *R. longepedicellatus* polyploids. The morphological similarity between the diploid and the segmental allopolyploids of *R. longepedicellatus* indicates that the structural chromosome changes in a genome were not accompanied by gene mutations which could produce morphological changes. The differences in chromosome pairing observed in different *R. × proteus* specimens at higher ploidy levels (Tables 3 & 5), might consequently be attributed to repeated hybridization between different *R. cuneifolius* B and *R. longepedicellatus* plants which differ in their structural chromosome changes.

Post-hybridization chromosomal evolution is due to structural changes in some chromosomes after hybridization. The occurrence of multivalents tends to increase meiotic instability and to lower fertility. Chromosome changes that will inhibit multivalent formation will, therefore, have a selective advantage due to the increased number of bivalents and the consequent increase in seed viability. These changes form part of the diploidization process. Different *R. × proteus* specimens may, therefore, represent different stages of diploidization and their meiotic chromosome pairing may consequently differ. However, the post-hybridization hypothesis only provides for autopolyploidization, whereas the pre-hybridization chromosome evolution hypothesis allows repeated hybridization between different ploidy levels or between plants at the same ploidy level but with different genomic constitutions. The pre-hybridization hypothesis is also supported by the greater morphological variation in *R. longepedicellatus* when compared with *R. cuneifo-*

lius B. This larger morphological variation might be the result of the segmental allopolyploid origin of the *R. longepedicellatus* polyploids.

Other interspecific hybrids and intersubgeneric hybrids have been described in the literature (See discussion under hybridization). In addition to the examples cited in the literature, the hybrid origin of certain taxa was inferred from their meiotic chromosome pairing. These taxa include *R. cuneifolius* A, *R. flagellaris*, *R. apetalus* and *R. pinnatus*. Chromosome pairing indicated that *R. flagellaris*, *R. apetalus* (Henderson & Gaum 6 and Wells 5000) and *R. pinnatus* are true allopolyploids; the 2:2 model of Kimber & Alonso (1981) was applicable and an x-value of 1 was obtained (Table 5). The tetraploid *R. cuneifolius* A specimen tends towards autopolyploidy, because the 3:1 model was applicable and the reduced x-value of 0,5 implied an affinity between the two sets of genomes. The other *R. apetalus* specimen, *G. Hemm s.n.*, conforms with the 2:1:1 model and has an x-value of 0,86. A specimen that appears to be an amphiploid between *R. transvaliensis* and *R. longepedicellatus* had an x-value of 1 when the 2:2 model was applied. No indication of a hybrid origin could be found for *R. affinis*, where the 4:0 model of Kimber & Alonso (1981) was applicable.

The results obtained by using the method described by Alonso & Kimber (1981) and Kimber & Alonso (1981) to a certain extent correspond with the results obtained by using the method described by Spies (1984). According to the latter method no specimens are true autopolyploids and Arnold 1335, *G. Hemm s.n.*, Henderson & Gaum 6, 14, 24, 27, 32, 51, 93, Stirton 5746, 9861 and 9868 are segmental allopolyploids and Henderson & Gaum 2, 10, Stirton 9798, 9862 and Wells 5000 are allopolyploids (Spies *et al.* 1985). The method of Spies (1984) further distinguishes between the segmental allopolyploids and indicates that Arnold 1335, Henderson & Gaum 14, 32 and Stirton 9861 tend towards allopolyploidy, whereas Henderson & Gaum 24, 27, 51, 93, Stirton 5746 and 9868 tend towards autopolyploidy. The rest of the specimens are intermediate segmental allopolyploids.

In contrast to the methods described by Alonso & Kimber (1981) and Kimber & Alonso (1981) and Spies (1984) the method described by Jackson & Casey (1982) and Jackson & Hauber (1982) suggests that all the plants are autopolyploids with partial random chromosome associations and 0–2 chiasmata per chromosome pair (Table 5). The reason why the latter method did not distinguish between different chromosomes in the specimens studied is that the initial assumption of the method, that the formation of chiasmata is random, does not apply in the genus *Rubus*. From random chiasma formation and a maximum of two chiasmata per chromosome pair, frequencies of 0,25, 0,5 and 0,25 are expected for chromosome pairs with no chiasmata, one chiasma and two chiasmata respectively. In the genus *Rubus* these figures are 0,08, 0,79 and 0,13. This deviation from the expected values indicates that this method is not applicable in the genus *Rubus*.

Hybridization

Hybridization in the genus *Rubus* is a topic as controversial as the taxonomy of the genus. Taxonomists

usually adhere to one of two extremes. Either every entity not fitting the species description exactly is regarded as a hybrid, or the occurrence of hybrids in the genus is totally ignored.

Bailey (1941–1945) described over 500 different species of *Rubus* for North America without the recognition of hybrids. He considered three points as essential for hybridization:

- (1) both parents must be in the vicinity of the hybrid;
- (2) hybrids occur in small numbers as incidental or as exceptions to the main population and
- (3) characters appear to belong to the parents in various degrees of combinations.

We support Bailey in his plea that all unidentifiable examples should not be regarded as hybrids. However, the validity of his three criteria for hybridization must be discussed before any conclusions can be made. His claim that both parents must be in the vicinity of the hybrid was usually fulfilled in the present study as the hybrids and the parental taxa often occurred together. However, hybrids were sometimes found with no parental form in the vicinity. This phenomenon may be attributed to one or more of several factors. Pollination by insects over large distances might occur and in such cases only the maternal parent need be in the vicinity. Seed could also have been transported from the mother plant by birds or man, dropping it far from the parental forms. This may be a common means of dispersal in southern Africa as the fruits of *Rubus* are relished by birds and man. One or both parents may die and only the hybrid may survive, especially in a weedy taxon like *Rubus* where hybrids might be very aggressive. Only one or neither parent need therefore be in the vicinity of the hybrid. The first of Bailey's criteria for hybridization is therefore invalid.

The second criterion claims that hybrids occur in small numbers as incidental or exceptions to the main population. This will be valid only for newly formed hybrids or weakly developed hybrids or species which have good barriers against hybridization. *Rubus* hybrids are often aggressive (Bammi 1964) and, due to hybrid vigour, they may exceed their parents and could become more abundant than either parental taxon. This is definitely the case with *R. × proteus* in the Graskop and Sabie areas of the Transvaal where the hybrids are exceptionally vigorous and are more abundant than the putative parents.

Characters do not have to be intermediate in the hybrids. They may exceed the ranges of both parents, new traits may be present in the hybrid or the traits of one parent may be absent in the hybrids due to dominance or epistasis. An example of the hybrid's trait exceeding that of its parents is found in the *R. trifidus* × *R. hirsutus* hybrid which has a larger flower diameter than either parent (Jinno 1957). In the present study it was observed that some hybrid specimens had longer rachises than either parent.

The three criteria for the determination of hybridity described by Bailey are, consequently, not always valid. These criteria are all based on morphological characters. Therefore, cytogenetic studies seem to be the only positive way of identifying hybrids. However, even this field is beset with problems and must be handled with extreme care to obtain meaningful results. This is illustrated by

the different results obtained when using the different methods described for analysing genome homology.

The consequences of hybridization in *Rubus* described in this paper are not restricted to the South African material. Interspecific and even intersubgeneric hybridization, giving rise to progeny that varies from completely fertile to totally infertile, has been described elsewhere (Crane & Darlington 1927; Crane & Thomas 1949; Heslop-Harrison 1953; Jinno 1955, 1957, 1958, 1959, 1961, 1963; Britton & Hull 1959; Haskell & Tun 1961; Thompson 1961; Bammi 1964; Naruhashi 1971, 1976, 1979; Naruhashi & Masaki 1980).

Morphological, reproductive and cytogenetic evidence indicates that hybridization does occur in the South African *Rubus* complex. Furthermore hybridization appears to take place on both the present taxonomic intrasubgeneric and intersubgeneric levels. The progeny derived from certain intersubgeneric hybridizations are fertile (Jinno 1958; Newton 1975).

Taxonomic implications of hybridization

In general, F_1 hybrids and their offspring cannot be considered to be separate species because they are sterile due to the failure of normal chromosome pairing during the meiotic process of sporogenesis. However, when hybridization is associated with, or followed by chromosome doubling, amphiploids are produced with normal chromosome pairing and good fertility. These new self-reproducing entities may be regarded as new species (Davis 1958) because the amphiploids are reproductively isolated from their parents. In the event of hybridization resulting in apomixis, each apomictic hybrid might represent a different genotypic combination of the sexual parents and a multitude of different self-reproducing entities can be formed. An increase in the degree of heterozygosity of the parental forms will result in an increase in the number of different recombinant entities. This array of apomictic self-reproducing entities, which are morphologically different from each other and genetically isolated, may on superficial study be regarded as separate species or microspecies. It is, however, unpractical to consider each of these apomictic hybrids as separate species, even if only obligate apomixis exists. In fact, they belong to an agamic complex without species boundaries which rests on pillars of sexual diploid (and polyploid) species. Only cytogenetical studies can distinguish between the true sexual species and the array of apomicts forming the agamic complex.

The fact that many *Rubus* species are restricted to very small geographical areas (Bailey 1941–1945; Davis & Davis 1951) could indicate that they represent either newly formed species or the abovementioned amphiploid apomicts. Apomixis is restricted to a small number of *Rubus* specimens in South Africa, i.e. the subgenus *Eubatus*. The tendency to describe a sexual hybrid as a separate species is frequently encountered in this genus. As an example the diploid species *R. toyorensis* and *R. nishimuranus* can be cited (Jinno 1957; Naruhashi 1971). The F_1 hybrid between the diploid species *R. trifidus* and *R. hirsutus* is regarded as a separate species, *R. toyorensis*, and the backcross of *R. toyorensis* to one of its parents is regarded as *R. nishimuranus*. In our opinion many of the described *Rubus* 'species' are only

hybrids. This has resulted in a totally artificial classification of the genus *Rubus*, where different morphological entities are regarded as separate biological species.

An example of the hybridization between different morphological 'species' is found in the species *R. apetalus* Poir., *R. exsuccus* Steud., *R. adolfi-friederici* Engl. and *R. ecklonii* Focke. Although these four 'species' are morphologically distinct, hybridization among them has produced more intermediate fertile specimens than typical specimens. In our opinion these four species belong to one biological species.

Spontaneous hybridization is less common among the indigenous *Rubus* species of southern Africa. It occurs between *R. rigidus* J. E. Sm. and *R. pinnatus* Willd. wherever these species are sympatric, e.g. *G. Hemm s.n.* in PRE and was described by Focke (1914). Hybridization between indigenous and introduced *Rubus* species is observed much more frequently. Such hybridization takes place between *R. fruticosus* L. agg. and *R. pinnatus* in disturbed areas of the Cape Peninsula (Adamson & Salter 1950). Other examples are *R. cuneifolius* A and *R. pinnatus* in Natal (*G. Hemm s.n.*) and *R. affinis* and *R. rigidus* described by Gustafsson (1933). All these cases involve hybridization between indigenous *Idaeobatus* and introduced *Eubatus* species. No hybrid swarms of any of these examples have been recorded to date.

CONCLUSIONS

The combination of morphological, geographical, reproductive and cytogenetic evidence revealed that natural hybridization occurs in the South African *Rubus* complex and also indicated that the hybridization is not restricted to intrasubgeneric hybridization, but that inter-subgeneric hybridization also occurs. The progeny derived from certain intersubgeneric hybridizations are fertile.

The application of the genome analysis method of Kimber & Alonso (1981) on the meiotic data indicated that all the tetraploid plants of *R. cuneifolius* B, *R. flagellaris*, *R. apetalus*, *R. longepedunculatus*, *R. pinnatus* and *R. × proteus* have two genomes that are more closely related to each other than to the other two genomes which are also related. This model indicates that all the plants are segmental allopolyploids with a tendency towards allopolyploidy. The model of Jackson & Casey (1982), on the other hand, indicates that all the plants are autopolyploids with partly random chromosome association. Totally different conclusions can, therefore, be drawn from the same meiotic data. Neither of the two models mentioned above distinguishes between any of the specimens studied. However, the chromosome configurations indicate that chromosome pairing varies between the different plants. These differences are accentuated by the model of Spies (1984). It is, therefore, concluded that the latter model is the most applicable for plants with very short chromosomes which have a low chiasma frequency, as is the case in the genus *Rubus* (Spies *et al.* 1985).

Finally, interspecific hybridization in the genus *Rubus*, without loss of fertility in the progeny, indicates that several of the morphological 'species' described in the past, belong to the same biological species. Since the difference in fertility levels between 'intersubgeneric' hybrids and 'interspecific' hybrids is negligible, it was

concluded that the present classification of the genus *Rubus* is very artificial and urgently needs a biosystematic revision.

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Ordination by detrended correspondence analysis (DCA) of the vegetation of Swartboschkloof, Jonkershoek, Cape Province

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Keywords: classification, detrended correspondence analysis, forest, fynbos, ordination, Swartboschkloof, vegetation ecology

ABSTRACT

The data of a Braun-Blanquet vegetation classification was ordinated using detrended correspondence analysis (DCA). This was done at the Fynbos Biome intensive study site, Swartboschkloof, Jonkershoek, to investigate the factors determining the distribution of the plant communities. Superimposition of environmental data on the DCA ordination confirmed the indications of the Braun-Blanquet classification that the distribution of plant communities is most strongly correlated with soil geology and, to a lesser extent, with soil moisture status. The ordination also proved useful for examining the relationships between the transitional communities and the distinct communities of Swartboschkloof.

UITTREKSEL

Die gegewens van 'n Braun-Blanquetplantegroei-klassifikasie is georden deur gebruik te maak van neigingsverwydering-oorrekenstommings-analise (DCA). Dit is by die intensiewe studieterrein van die Fynbosbiom, Swartboschkloof, Jonkershoek, gedoen om die faktore wat die verspreiding van die plantgemeenskappe bepaal, te ondersoek. Deur die omgewingsdata op die DCA-ordening te plaas, is die aanduidings van die Braun-Blanquetklassifikasie bevestig dat die verspreiding van plantgemeenskappe die sterkste met grondgeologie en in 'n minder mate met grondvogstatus gekorreleer is. Dit blyk ook dat die ordening nuttig is om die verhoudings tussen oorgangsgemeenskappe en die bepaalde gemeenskappe van Swartboschkloof te ondersoek.

INTRODUCTION

Details of the physiography of the Swartboschkloof study site (Fynbos Biome Project) are given by Van der Merwe (1966), Werger, Kruger & Taylor (1972) and McDonald (1983, 1985). Werger *et al.* (1972) tested the Braun-Blanquet (B-B) method (Mueller-Dombois & Ellenberg 1975; Werger 1974) in the floristically rich vegetation of Swartboschkloof and classified the vegetation from 44 relevés. Eleven years later McDonald (1983 & 1985) re-surveyed Swartboschkloof more intensively and extensively (201 relevés) using the B-B phytosociological method with the objectives of re-classifying, mapping the vegetation and relating the plant communities to the environment.

Classification of the Swartboschkloof vegetation resulted in the description of 21 plant communities which were then mapped. The relationships between the plant communities and the environment were, however, not clear. The classification suggested that the plant communities are related to soil geology and soil moisture status, indicating a need for further data analysis using ordination.

Numerous ordination methods have been tested using simulated and field data, with the objective of establishing which method summarizes ecological data most effectively in 'low-dimensional space' (see Gauch 1982, for review of the literature). Detrended correspondence analysis (DCA) (Hill 1979) stands out as the most suitable ordination method for community analysis for very heterogeneous communities (Hill & Gauch 1980; Gauch 1982). Recent application of DCA includes studies in island vegetation of the Channel Islands off the coast of southern California (Westman 1983), in Tasmanian vegetation (Brown, Ratkowsky & Minchin 1984), in hazel

scrub in northeast Ireland (Cooper 1984) and in savanna, forests, woodlands and grasslands in South Africa (Lubke, Morris, Theron & Van Rooyen 1983; Theron, Morris & Van Rooyen 1984; Whittaker, Morris & Goodman 1984; Deall 1985). The widespread trend towards the use of DCA in studies of vegetation, its robustness, low demands on computer-processing and its ease of output interpretation (Gauch 1982) were positive indications for application of DCA in analysing the Swartboschkloof vegetation data.

METHODS

Data were collected from 201 plots in the study area. One hundred of these were placed as close as possible to soil pits (Fry in prep.). In the fynbos vegetation 50 m² rectangular plots and in the forest vegetation 200 m² rectangular plots were used. In the fynbos samples, the long axes of the plots were aligned with the contour to avoid downslope variation. The forests are often narrow, so downslope orientation of the forest sample plots was necessary.

Species cover-abundance estimates were made using the Braun-Blanquet scale. Structural data of the vegetation were collected as were site-related data such as land-facet, altitude, slope, aspect and geology. Cover of surface rocks, litter and projected canopy cover of the vegetation were estimated on a percentage scale at each sample site. Data on the soils were obtained from Fry (in prep.).

Since the data collected by Werger *et al.* (1972) are compatible with those of this study, they were added to the data set for further analysis (see below).

Classification

The data were arranged in a two-way species-by-samples matrix and sorted with the aid of the TABSORT

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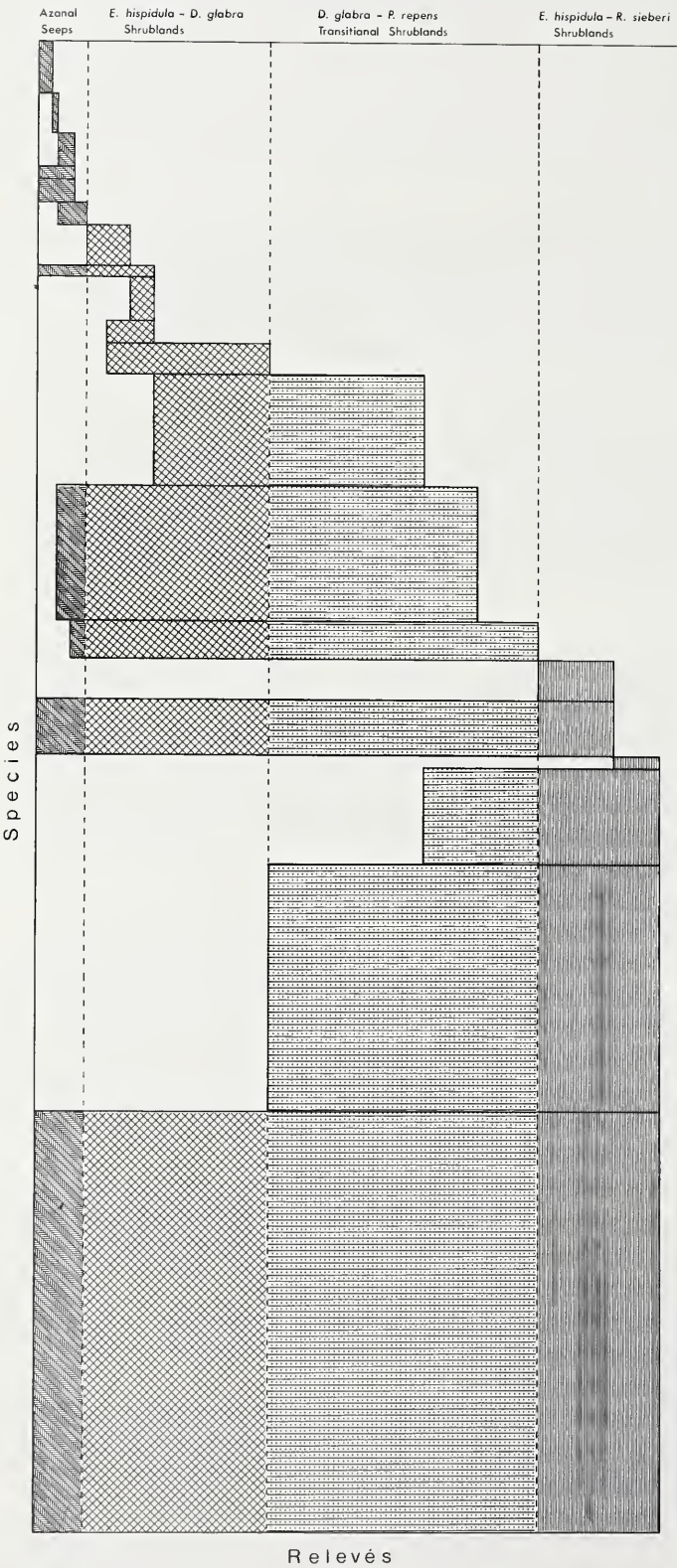


FIGURE 1.—Diagram of the Braun-Blanquet table of the Mountain Fynbos shrublands of Swartboschkloof (after McDonald 1983).

computer program (Boucher 1977). After initial sequencing, it became clear that it would be necessary to separate the fynbos samples from the forest samples, to treat them in separate tables. This distinction reflects the two vegetation types recognized: Mesic Mountain Fynbos (*sensu* Moll, Campbell, Cowling, Bossi, Jarman & Boucher 1984) and Afromontane Forest (White 1978).

The Mountain Fynbos table diagrammatically represented in Figure 1 was systematically sorted to give 20 groups. Of these, 17 groups were characterized as specialized communities. Two of the three remaining groups consist of species with wide ecological tolerance but with certain differential species of the specialized communities absent. The third of the latter three groups represents the widespread species in the fynbos vegetation of Swartboschkloof.

A similar procedure was followed with the forest vegetation data (Figure 2). Sequencing of the species-by-samples matrix resulted in seven groups. Three of these groups (3, 5 and 6 in Figure 2) were distinguished as true remnant Afromontane Forest communities; Groups 1 and 2 are communities transitional between fynbos and forest vegetation and Groups 4 and 7 represent species transgressive between the fynbos/forest transitional communities and the Afromontane Forest communities.

Ordination

The computer program DECORANA (Hill 1979) was used to ordinate the data. A number of options are open to the user of DECORANA. For the purposes of this study the standard or default option was used. The program also allows data subsets to be extracted from the whole data matrix so that different parts of the matrix may be ordinated separately (Peet 1980). The results of the DCA presented here therefore have the following limitations:

- (a) the standard or default option was used throughout for all parameters except number of samples;
- (b) number of samples and samples selected varied according to each respective ordination; and
- (c) DCA scores for Axes I and II only are presented because the eigenvalues for these axes were closest to unity (1) in all cases.

The evaluation of DCA here is not a comparison with other ordination methods to establish its effectiveness. Rather, it is an evaluation to see what information it may provide additional to that given by the classification (McDonald 1983 & 1985). The 'standard two-step procedure' (Gauch 1982) was followed in the analysis:

(a) Summary of community patterns

The three groups of fynbos shrublands, the azonal seep communities, the forest communities and the fynbos-forest ecotonal communities determined in the classification, were superimposed on the ordination using different symbols. Firstly, the full data set (McDonald 1983 & 1985) was analysed (Figure 3), then the forest data were removed and the residual data analysed (Figure 4). Thirdly, the data from the azonal seeps and the forests were excluded and the remaining data ordinated (Figure 5). In order to test for a 'disjunction' between the

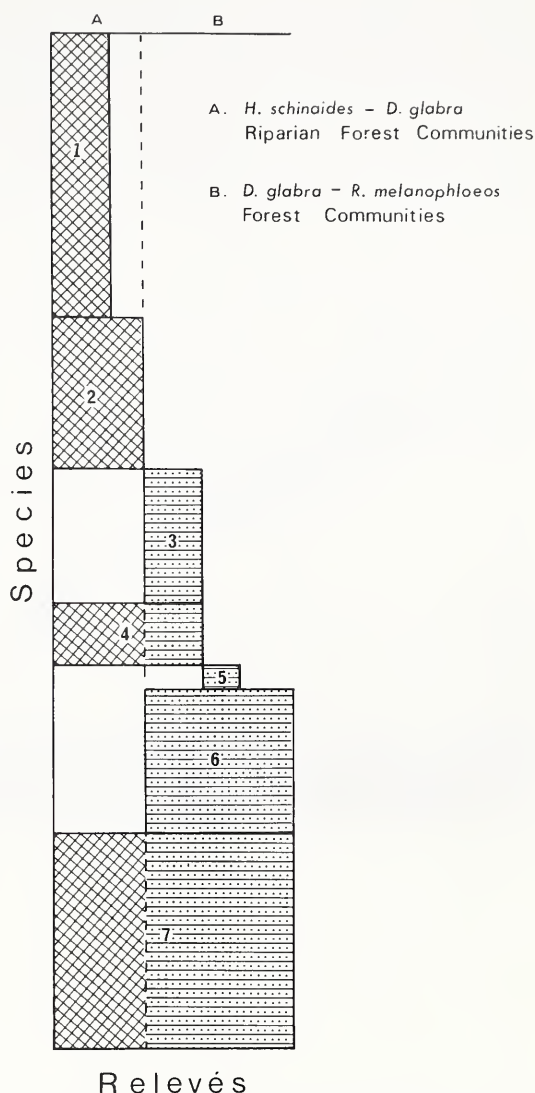


FIGURE 2.—Diagram of the Braun-Blanquet table of the forest vegetation of Swartboschkloof (after McDonald 1983). 1 and 2, transitional between fynbos and forest communities; 3, 5 and 6, true remnant Afromontane Forest communities; 4 and 7, transgressive species between fynbos/forest transitional communities and Afromontane Forest communities. A, *Hartogiella schinoides*–*Diospyros glabra*; B, *Diospyros glabra*–*Rapanea melanophloeos*.

Erica hispidula–*Diospyros glabra* Shrublands and the *Erica hispidula*–*Restio sieberi* Shrublands, the data from the *D. glabra*–*Protea repens* Transitional Shrublands were excluded (Figure 6). Finally, the data from the Werger *et al.* (1972) survey were added to the above-mentioned full data set, with the objective of examining (a) the effect of additional data on the ordination and (b) the interpretation of the Werger *et al.* (1972) study in terms of the more recent classification (Figure 7).

(b) Comparison of community patterns with available environmental data to give an environmental interpretation of the ordination

The following environmental parameters were symbolically superimposed on the scatter plot representing

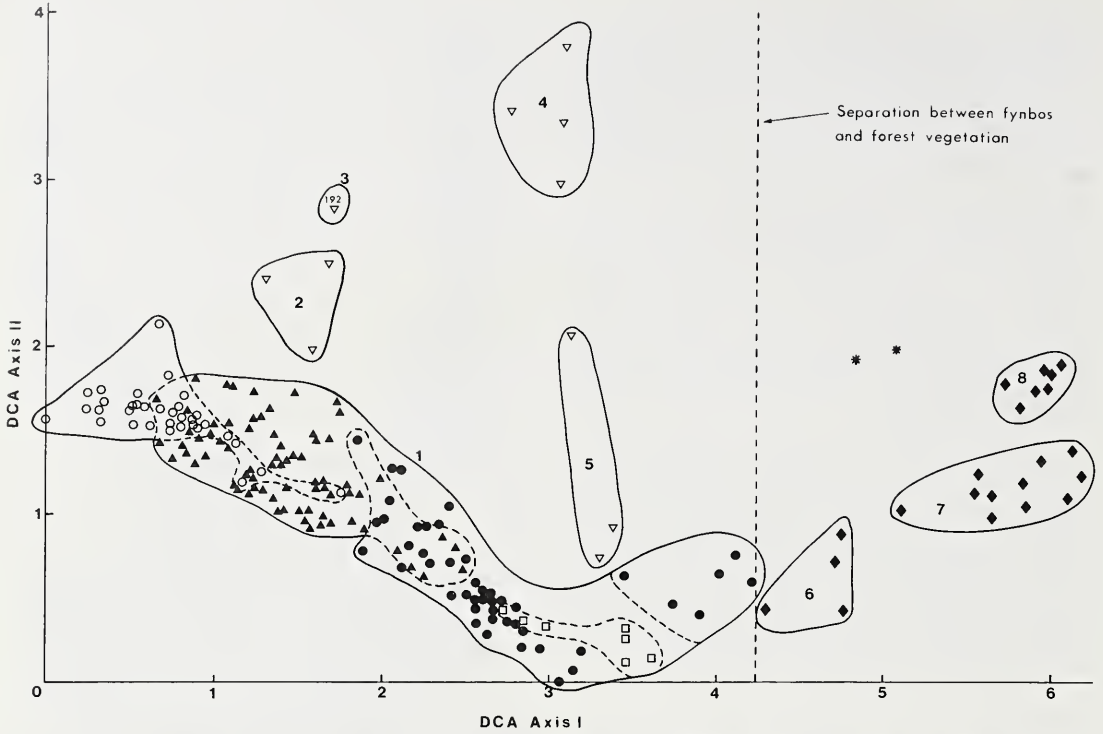


FIGURE 3.—Ordination (DCA) of the whole data set from McDonald (1983) ◆, Afromontane Forest; ▽, azonal seep communities; ○, *Erica hispidula-Restio sieberi* Shrublands; ▲, *Diospyros glabra-Protea repens* Transitional Shrublands; ●, *E. hispidula-Diospyros glabra* Shrublands; □, *Halleria elliptica-Cliffortia cuneata* Shrubland; *, poor relevés. 1, Mesic Mountain Fynbos communities; 2-5, seep communities; 6, *Halleria elliptica-Brabejum stellatifolium* Short Forest; 7, boulder scree forests; 8, streambank forest.

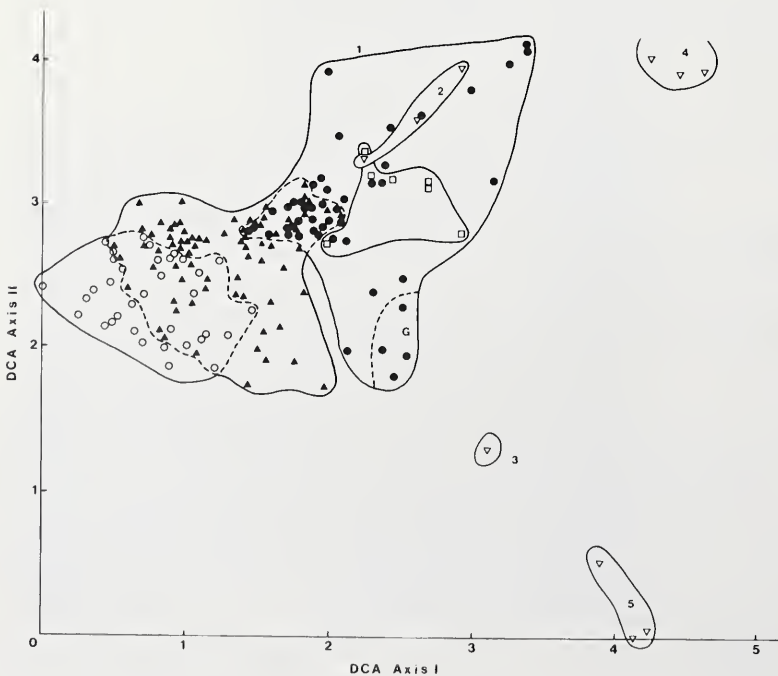


FIGURE 4.—Ordination (DCA) of the data from the Mountain Fynbos (McDonald 1983) to demonstrate the relationships between the azonal seeps and fynbos; data from the Afromontane Forest communities are excluded. ○, *Erica hispidula-Restio sieberi* Shrublands; ▲, *Diospyros glabra-Protea repens* Transitional Shrublands; ●, *Erica hispidula-Diospyros glabra* Shrublands; □, *Halleria elliptica-Cliffortia cuneata* Shrubland; ▽, seep communities. 1, Mesic Mountain Fynbos communities; 2-5, seep communities. G, *Myrsine africana-Cliffortia dentata* Shrubland. One relevé is omitted from cluster 4 in this diagram.



FIGURE 5.—Ordination (DCA) of the Mountain Fynbos data only; azonal seep and forest vegetation data are excluded. ○, *Erica hispidula*–*Restio sieberi* Shrublands; ▲, *Diospyros glabra*–*Protea repens* Transitional Shrublands; ●, *Erica hispidula*–*Diospyros glabra* Shrublands. G, *Myrsine africana*–*Cliffortia dentata* Shrubland with 29 & 30 denoting two relevés representing this community (see text). E/F, a cluster of relevés from the closely related *Rhus angustifolia*–*Myrsine africana* and *Myrsine africana*–*Olea europaea* subsp. *africana* Shrubland communities. (Note: the communities represented by the symbols G and E/F fall within the *Erica hispidula*–*Diospyros glabra* Shrublands, hence the use of the symbol ●.)

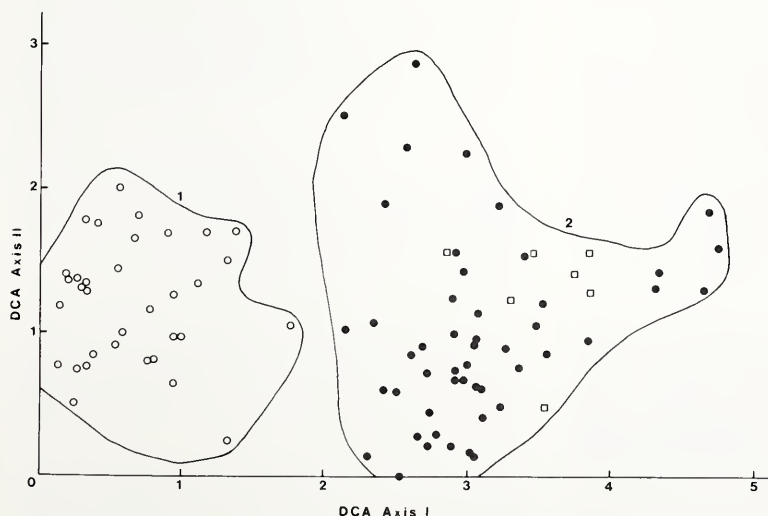


FIGURE 6.—Ordination (DCA) of the Mountain Fynbos data, excluding data from the transitional fynbos communities reveals the disjunction between the *Erica hispidula*–*Diospyros glabra* Shrublands, ○, and the *Erica hispidula*–*Restio sieberi* Shrublands, ●. The open squares, □, represent the *Halleria elliptica*–*Cliffortia cuneata* Shrubland, indicating its affinity to the *E. hispidula*–*R. sieberi* Shrublands.

the ordination of the augmented data set: altitude, aspect, slope, geology, soil form, soil series, percentage cover of rocks and relative moistness or dryness of each sample site. Only soil geology and soil moisture showed positive

correlation with plant community distribution (Figure 8). Results for the other environmental parameters are therefore not presented.

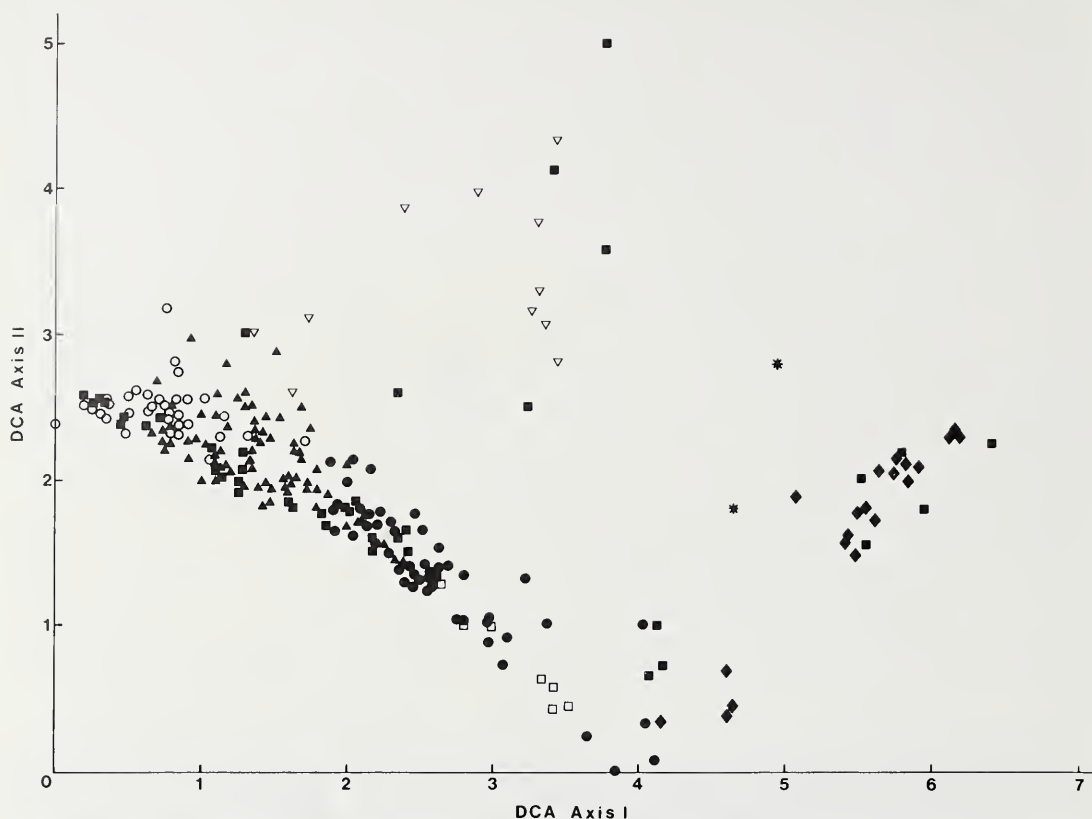


FIGURE 7.—Ordination (DCA) of the whole data set (McDonald 1983) augmented with data from Werger *et al.* (1972). ◆, Afromontane Forest; ▽, seep communities; ○, *Erica hispidula*–*Restio sieberi* Shrublands; ▲, *Diospyros glabra*–*Protea repens* Transitional Shrublands; ●, *Erica hispidula*–*Diospyros glabra* Shrublands; ■, *Halleria elliptica*–*Cliffortia cuneata* Shrubland; *, poor relevés; ■, Werger *et al.* (1972) relevés.

RESULTS AND DISCUSSION

Classification of the Mesic Mountain Fynbos

The diagrammatic table representing the Mesic Mountain Fynbos communities (Figure 1) was subdivided into three main sections; each section represents a group of communities. The first group (top left of diagram, Figure 1) is the *Erica hispidula*–*Diospyros glabra* Shrublands. These shrublands occur on soils of granite or colluvial derivation in the mid-central part of the study area. Included in this group are the essentially azonal 'seep' communities which are only included here for convenience of table sorting.

The second group (centre of diagram, Figure 1), the *Diospyros glabra*–*Protea repens* Transitional Shrublands is found on the ecotone between the above-mentioned first group and the third group (right-hand side of Figure 1). The third group is the *Erica hispidula*–*Restio sieberi* Shrublands associated with shallow sandstone-derived soils above 750 m elevation.

From an applied research and management viewpoint it was necessary to know which of the above groups represented groups of easily identifiable communities. As mentioned, the classification indicated the existence of two distinct fynbos community groups and one transitional group, but there was doubt as to whether it could

clearly define the relationships of these groups to each other.

The classification of the fynbos vegetation (apart from the azonal seep communities) also pointed to a strong relationship between the pattern of community distribution and soil parent material at Swartboschkloof. No other environmental factors appeared to be as strongly correlated with fynbos community distribution as soil geology. However, the possibility that one or more other factors such as availability of water, soil-water retention, slope, altitude and so on, also markedly affect community distribution could not be ruled out.

Classification of the remnant Afromontane Forest

The classification of the forest vegetation (Figure 2) shows that the two communities transitional between fynbos and forest are found on colluvial soils. *Brabejum stellatifolium* (wild almond) and the fern *Blechnum australe* are two species common to the transition communities and the forests along the perennial streams. This community can in turn be separated from the *Diospyros glabra*–*Rapanea melanophloeos* Tall Forest by the presence of water-loving species such as *Cunonia capensis* and *Ilex mitis*. Both granite and sandstone boulders are found in the streambeds. However, percentage rock cover in the streambeds is 30 % less on average than on the sandstone boulder screes where the *D. glabra*–*R.*

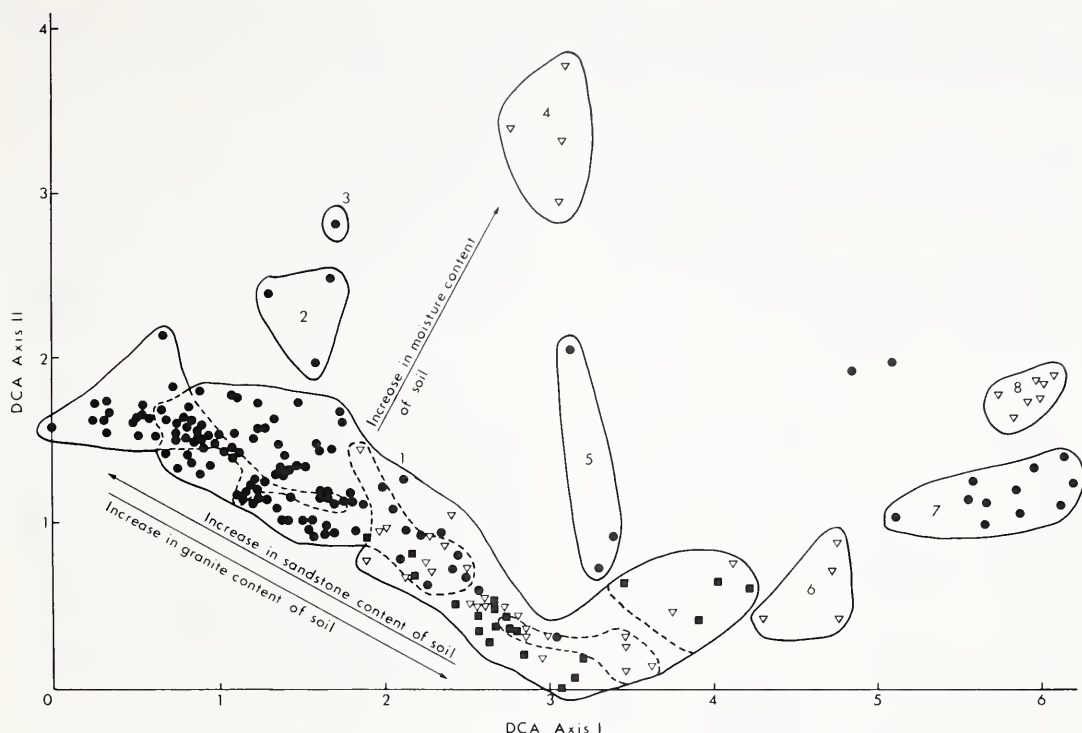


FIGURE 8.—Ordination (DCA) of the whole data set (McDonald 1983) with soil geology symbolically superimposed on the scatter of points. Sandstone-derived soil, ●; colluvial soil, ▽; granite-derived soil, ■.

melanophloeos Tall Forest and the *R. melanophloeos-Heeria argentea* Short Forest are found. The latter two communities are very similar; they are separated by the respective absence and presence of *H. argentea*.

Floristic similarity of the two communities constituting the remnant Afromontane Forest in Swartboschkloof indicated the need for further testing of the forest data as well, to establish whether the separation of this vegetation into three communities is justified.

Ordination

(a) Summary of community patterns

In the first analysis, the whole data set of the Swartboschkloof vegetation was analysed using DECORANA and the results plotted in a scatter diagram (Figure 3).

The separation of the Afromontane Forest (◆) from the Mountain Fynbos is immediately apparent; this indicates the difference between these two vegetation types. The seep communities (▽), although part of the fynbos, are distinctly separate and are also not linked to each other.

If the forest vegetation is considered first (Figure 3), it is seen that there are three clusters of points. The first (cluster 6) represents the *Halleria elliptica-Brabejum stellatifolium* Short Forest which, although it is more forest-like, is transitional between fynbos and forest. Cluster 7 represents the forests on the boulder scree. This group of samples was split into two communities in the classification, based on presence and absence of *Heeria argentea*. It is therefore significant that the ordi-

nation clusters these samples together. Cluster 8 represents the streambank forest which is distinct from the boulder scree forests.

The fynbos vegetation is more complex than the forest vegetation and boundaries are not clear-cut, except for those of the seep communities (clusters 2, 3, 4 & 5) as noted above (Figure 3).

The community represented by 'cluster' 3 is characterized in the classification on the basis of one sample (192). This is unsatisfactory but the ordination shows that it has close affinity to the seep community represented by cluster 5. In Swartboschkloof this community is very localized but seeps with similar species composition have been noted in other parts of the Hottentots-Holland Mountains.

The intergrading of the Mesic Mountain Fynbos communities shown by the classification is borne out by the ordination (Figure 3, cluster 1). There is a more or less continuous scatter of points along Axis I which are then spread vertically by Axis II. By superimposing the three groups of fynbos communities defined in the classification, (McDonald 1983, 1985) the 'continuum' nature of the fynbos shrublands is demonstrated. The open circles (○) represent the *Erica hispidula-Restio sieberi* Shrublands; the shaded triangles (▲) represent the *Diospyros glabra-Protea repens* Transitional Shrublands and the shaded circles (●) represent the *E. hispidula-D. glabra* Shrublands. The open squares (□) represent one of the ecotonal communities, the *Halleria elliptica-Cliffortia cuneata* Shrubland transitional between fynbos and forest. Asterisks (*) denote poor samples. The difficulty

experienced in defining clear-cut community boundaries in the classification of the Mesic Mountain Fynbos is thus explained by the 'continuum' apparent in the ordination.

To investigate the relationship of the azonal seep communities (∇) to the fynbos communities, the forest data were excluded. The analysis (Figure 4) shows that seep communities 5 and 4 are close together on Axis I but widely separated on Axis II and although seep community 3 is unique it is closer to 5 on Axis II. At the same time, seep community 2 is close to 3 on Axis I yet close to 4 on Axis II. Community 2 is also more closely allied to the fynbos communities. Interpretation of this pattern with respect to the environment is discussed below.

The relationship of the fynbos vegetation groups to one another was investigated by removing the forest and seep data. The scatter of points in Figure 5 is more spread out along both Axes I and II because the limiting effect of the seep and forest data on the ordination is absent. This ordination does not differ significantly from the analysis in which the data for the fynbos and seep communities are included. The fynbos 'continuum' is still obvious but in addition the ordination has separated two clusters of samples from the main scatter of points. The first cluster (G in Figure 5) is a cluster of four relevés representing the *Myrsine africana*-*Cliffortia dentata* Shrubland. There were some doubts when classifying the vegetation as to whether relevés 29 & 30 (see Figure 5) actually represented this community. In the classification the decision was made to retain these two relevés as representing this community. The ordination vindicated this decision by clustering the four relevés of the above-mentioned community, including relevés 29 & 30, together.

The second cluster (E/F in Figure 5) consists of relevés from two communities (the *Rhus angustifolia*-*Myrsine africana* Shrubland and the *Myrsine africana*-*Olea europaea* subsp. *africana* Shrubland) closely related in the classification. This may be interpreted in two ways: (1) that, based on the floristic composition, the classification has made finer distinction between relevés than that achieved by DCA; or (2) that the ordination has clustered these relevés on the basis of some factor or factors not obvious in the classification.

Checking of the higher axes of DCA did not reveal any further reason for the differences observed between the classification and the first two dimensions of DCA. The disjunction between the *Erica hispidula*-*Diospyros glabra* and *E. hispidula*-*Restio sieberi* Shrublands can be demonstrated if the data of the seeps, forests and transitional fynbos communities are excluded, and the remaining data ordinated (Figure 6). Since the intergrading transitional communities have been omitted, the disjunction between the two above-mentioned fynbos groups is not real. However, the ordination serves to show the relationship of these two groups to each other without the modifying effect of the data from the ecotonal communities.

The inclusion of data from Werger *et al.* (1972) (solid black squares in Figure 7) caused more definite clustering in the ordination; compare Figures 3 & 7 (augmented data set). It shows that sampling in the Werger *et al.*

study was more selective, particularly in that no samples were taken towards the 'lower' end of the fynbos gradient (DCA Axis I: 275-400 in Figure 7).

(b) Environmental interpretation

The habitat data collected at each site were superimposed on the ordination to test which factors were influencing the distribution of the plant communities. The interaction of environmental factors is complex and it is difficult to isolate one factor that has an overriding effect on vegetation pattern. No meaningful conclusions could be drawn when slope, aspect, altitude and percentage rock cover were superimposed on the ordination. This is attributed to the grossness of these factors; the vegetation is apparently sensitive to more specific habitat factors. The data for the soils of Swartboschkloof are not comprehensive (M. Fry pers. comm.) therefore parameters such as soil pH, percentage organic C, available N and P, particle-size distribution and soil-water retention properties could not be applied to the ordination to investigate their effects. The lack of these data prevented conclusive quantitative testing of the hypothesis that available soil moisture is one of the major determinants of vegetation patterns in Swartboschkloof. The ordination of the augmented data set gives the clearest definition of the environmental gradients. The moisture gradient is more or less at right-angles to the gradient associated with the soil parent material (Figure 8).

If the ordination of the fynbos is considered separately, there is a clear diagonal gradient from shallow sandstone-derived soils (left) to colluvial and granite-derived soils (right) on Axis I. This corresponds well with the pattern of fynbos community distribution: the *Erica hispidula*-*Restio sieberi* Shrublands and the *Diospyros glabra*-*Protea repens* Transitional Shrublands are associated with sandstone-derived soils whereas the *Erica hispidula*-*Diospyros glabra* Shrublands are found on colluvial or granite-derived soils. The hypothesis that soil parent material is a major determinant of fynbos community distribution in Swartboschkloof is therefore upheld.

Owing to the azonality of seeps and their dependence on phreatic water, it is not easy to relate their occurrence to soil geology. Correlation exists between seeps 2, 3 & 5 (Fig. 8) and sandstone-derived soils. Seep 4 is associated with colluvial soils in a bottomland situation, which could account for its remote displacement from the other seep communities in the ordination. With the forest communities it is found that the *Halleria elliptica*-*Brabejum stellatifolium* Forest and the *Rapanea melanophloeos*-*Cunonia capensis* Forest both occur on colluvial soils. They are, however, not close together in the ordination. This separation is attributed to differences in the water regime: the former community is found along drier seasonal drainage lines and the latter along moist perennial streams.

The forests on the sandstone boulder scree are thought to be associated with the irregular nature of the substrate. It would be difficult to prove that they owe their existence to the presence of sandstone rather than granite boulders, as one may be tempted to conclude from the ordination.

CONCLUSIONS

The detrended correspondence analysis has proved useful in that it has enhanced understanding of the relationships of the plant communities in Swartboschkloof. The ordination did not give much more information than was already known from critically analysing the classification, but it portrayed the communities in 'ecological space' of low dimensions which was helpful when relating communities or groups of communities to each other. An additional advantage of using DCA is that it effectively conveys information to researchers who are familiar with ordination techniques but unfamiliar with the Braun-Blanquet approach.

The clear distinction between Mountain Fynbos and Afromontane Forest was shown together with the position of the communities transitional between these two vegetation types. It was also possible to clearly demonstrate the 'continuum' nature of the fynbos vegetation. However, the distinct difference between the *Erica hispidula*-*Diospyros glabra* Shrublands and the *E. hispidula*-*Restio sieberi* Shrublands could be shown by removing the transitional fynbos communities, the seep communities and the forest communities from the data set. In the ordination the affinity of the seep communities to the fynbos is evident but their uniqueness stands out.

The unfortunate lack of soil data prevented an in-depth study of the effects of important soil parameters such as pH, organic carbon, available N and P, and soil moisture. However, the relative wetness-dryness assessment of sample sites gave sufficient information to show that soil moisture plays a secondary role in determining plant community distribution patterns. Application of the soil parent material data to the ordination supports the hypothesis that soil geology plays the major part in determining the distribution of the plant communities, particularly of the Mountain Fynbos, in Swartboschkloof.

ACKNOWLEDGEMENTS

The assistance of the following people is gratefully acknowledged: Mr J. H. Engelbrecht and Miss P. D. Strydom (Winter Rainfall Region, Department of Agriculture and Water Supply); Mr C. Boucher of the University of Stellenbosch and Miss M. Morley, Botanical Research Unit, Stellenbosch. Professor G. J. Bredenkamp, Dr J. C. Scheepers and Messrs H. G. Gauch Jr and A. Rebelo kindly commented on the manuscript.

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Miscellaneous notes

VARIOUS AUTHORS

CHROMOSOME STUDIES ON AFRICAN PLANTS. 3.

The presentation of chromosome numbers in this report conforms with the format described in the first publications of this series (Spies & Du Plessis 1986 a & b).

POACEAE

Arundinelleae

Arundinella nepalensis Trin.: **n = 10, ~35.**

TRANSVAAL.—2530 (Lydenburg): 31 km from Lydenburg to Roosenekal (–AB), *Spies 1615* (n = 10); Frischgewaagd Farm near Dullstroom (–AC), *Spies 1571* (n = ~35).

Tristachya leucothrix Nees: **n = 24.**

TRANSVAAL.—2430 (Pilgrim's Rest): Mac-Mac Waterfalls (–DD), *Spies 1433a*.

Andropogoneae

Sorghum bicolor (L.) Moench. subsp. *arundinaceum* (Desv.) De Wet & Harlan: **n = 20.**

TRANSVAAL.—2529 (Witbank): 10 km from Belfast to Stoffberg (–DB), *Spies 1637*.

Bothriochloa insculpta (A. Rich.) A. Camus: **n = 30.**

TRANSVAAL.—2529 (Witbank): 67 km from Lydenburg to Roosenekal (–BB), *Spies 1624*.

Andropogon eucomus Nees: **n = 10, 20.**

TRANSVAAL.—2430 (Pilgrim's Rest): Blyderivierspoort Nature Reserve (–DB), *Spies 1428a* (n = 10). 2530 (Lydenburg): 31 km from Lydenburg to Roosenekal (–AB), *Spies 1608* (n = 20).

CAPE.—3228 (Butterworth): near Cintsa-West turnoff on road from East London to Butterworth (–CC), *Spies 1677* (n = 10).

Andropogon huillensis Rendle: **n = ~50.**

TRANSVAAL.—2529 (Witbank): 10 km from Belfast to Stoffberg (–DB), *Spies 1642*.

Cymbopogon plurinodis (Stapf) Stapf ex Burtt Davy: **n = 10.**

CAPE.—3225 (Somerset East): 7 km from Somerset East to Pearston (–CB), *Spies 1131*.

Cymbopogon prolixus (Stapf) Phill.: **n = 20.**

TRANSVAAL.—2530 (Lydenburg): 6 km from Goede Hoop to Roosenekal (–AA), *Spies 1494*.

Hyparrhenia dregeana (Nees) Stapf: **n = 10.**

TRANSVAAL.—2529 (Witbank): 67 km from Lydenburg to Roosenekal (–BB), *Spies 1634*.

Panicaceae

Digitaria diagonalis (Nees) Stapf var. *diagonalis*: **n = 18.**

CAPE.—3228 (Butterworth): near Sunrise-On-Sea (–CC), *Spies 1663*.

Digitaria eriantha Steud.: **n = 18.**

TRANSVAAL.—2430 (Pilgrim's Rest): 23 km from Boshhoek to Olifantshoek (–CD), *Spies 1544*.

Digitaria monodactyla (Nees) Stapf: **n = 9, 18.**

TRANSVAAL.—2530 (Lydenburg): 6 km from Goede Hoop to Roosenekal (–AA), *Spies 1492* (n = 18); 41 km from Goede Hoop to Roosenekal (–AA), *Spies 1592* (n = 9), *1597* (n = 18).

Digitaria natalensis Stent: **n = 9.**

CAPE.—3228 (Butterworth): near Cintsa-West turnoff on road from East London to Butterworth (–CC), *Spies 1676*.

Paspalum dilatatum Poir.: **n = 20, 25.**

TRANSVAAL.—2530 (Lydenburg): 31 km from Lydenburg to Roosenekal (–AB), *Spies 1611* (n = 20).

CAPE.—3225 (Somerset East): Daggaboersnek Pass (–DB), *Spies 1110* (n = 20). 3227 (Stutterheim): Kabusie Forest (–CB), *Spies 1698* (n = 25). 3228 (Butterworth): near Sunrise-On-Sea (–CC), *Spies 1667* (n = 20).

Paspalum urvillei Steud.: **n = 20.**

TRANSVAAL.—2530 (Lydenburg): 31 km from Lydenburg to Roosenekal (–AB), *Spies 1612*.

Paspalum sp.: **n = 20.**

TRANSVAAL.—2529 (Witbank): 15 km from Stoffberg to Belfast (–BD), *Spies 1444a*.

Brachiaria subulifolia (Mez) Clayton: **n = 18.**

TRANSVAAL.—2430 (Pilgrim's Rest): Mac-Mac Waterfalls (–DD), *Spies 1433*.

Setaria sphacelata (Schumach.) Moss var. *sericea* (Stapf) Clayton: **n = 18.**

CAPE.—3228 (Butterworth): near Cintsa-West turnoff on road from East London to Butterworth (–CC), *Spies 1673*.

Pennisetum macrourum Trin.: **n = 7, ~60.**

TRANSVAAL.—2530 (Lydenburg): Frischgewaagd Farm near Dullstroom (–AC), *Spies 1570* (n = ~60); Goede Hoop Farm near Lydenburg (–AC), *Spies 1579* (n = 7 + 0–4B).

Pennisetum thunbergii Kunth: **n = 9.**

TRANSVAAL.—2530 (Lydenburg): 15 km from Dullstroom to Goede Hoop (–AC), *Spies 1459*.

Cenchrus ciliaris L.: **n = 29/2.**

CAPE.—3325 (Somerset East): 51 km from Port Elizabeth to Jansenville (–AC), *Spies 1650*.

Rhynchelytrum nerviglume (Franch.) Chiov.: **n = 18, 36.**

TRANSVAAL.—2530 (Lydenburg): 6 km from Goede Hoop to Roosenekal (–AA), *Spies 1487* (n = 18), *Spies 1490* (n = 36).

Rhynchelytrum repens (Willd.) C. E. Hubb.: **n = 18.**

TRANSVAAL.—2530 (Lydenburg): Goede Hoop Farm near Lydenburg (–AC), *Spies 1591*.

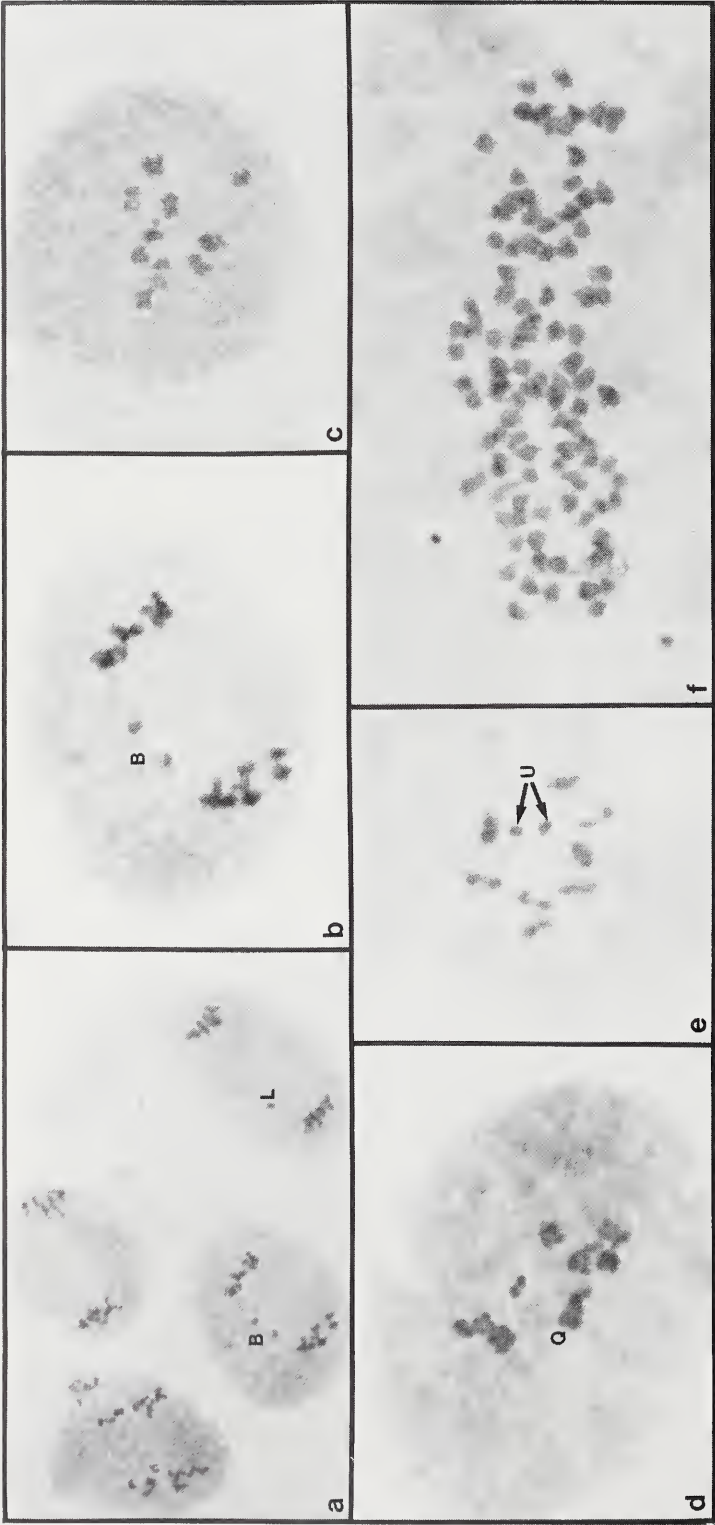


FIGURE 1.—Meiotic cells: a-c, *Arundinella nepalensis*, Spies 1615; d, *Hyparrhenia dregeana*, Spies 1634; e, *Digitaria monodactyla*, Spies 1592; f, *Andropogon huillensis*, Spies 1642. a, anaphase I, note the laggard (L) and the chromosome bridge (B); b, enlargement of the chromosome bridge in a; c, diakinesis showing 10; d, diakinesis showing one quadrivalent (Q); e, diakinesis with two univalents (U); f, early anaphase I. Scale: a, $\times 1500$; b-f, $\times 2500$.

Stipeae

Stipa dregeana Steud. var. *elongata* (Nees) Stapf: $n = 24$.

CAPE.—3227 (Stutterheim): Kabusie Forest (—CB), *Spies* 1693.

DISCUSSION

The chromosome numbers presented in this article conform in most instances to published results for the same species, or for other species of the genus (Darlington & Wylie 1955; Ornduff 1967–1969; Fedorov 1969; Moore, R. J. 1970–1977; Moore, D. M. 1982; Goldblatt 1981 & 1984).

Deviations from the expected chromosome numbers were observed in two different specimens. The somatic chromosome number of $2n = 40$ given for *Sorghum bicolor* subsp. *arundinaceum* (*Spies* 1637) deviates from the expected somatic number of 20 described by Celarier (1958 & 1959), Harlan & De Wet (1972), De Wet (1978) and *Spies* (1980). The other exception is *Cenchrus ciliaris* (*Spies* 1650) where a somatic chromosome number of 29 clearly indicates the aneuploid nature of the specimen.

Meiotic chromosome pairing was abnormal in a significant number of the specimens studied. Abnormalities were observed in the following species:

1, *Arundinella nepalensis* (*Spies* 1615): this supposed diploid plant exhibited a rather abnormal meiosis with up to three laggards during anaphase I (Figure 1a–c);

2, *Tristachya leucothrix* (*Spies* 1433a): one trivalent and one univalent were observed in one cell of this specimen;

3, *Hyparrhenia dregeana* (*Spies* 1634): meiotic chromosome analysis of this presumed diploid specimen indicated that chromosome configurations varied from $10_1 5_{II}$ to 5_{IV} , with $6_{II} 2_{IV}$ the most common form (Figure 1d). This unexpected multivalent formation in a supposed diploid specimen seems to indicate that this species has a basic chromosome number of five rather than a basic number of ten and the plant is, therefore, tetraploid and not diploid;

4, *Digitaria monodactyla* (*Spies* 1592): two univalents per cell were observed in two cells of this diploid specimen (Figure 1e);

5, *Paspalum dilatatum*: all specimens indicated abnormal meiotic chromosome behaviour. In *Spies* 1110 univalents were observed during metaphase I and up to nine laggards were present during anaphase I. Another tetraploid specimen, *Spies* 1611, also had abnormal chromosome pairing resulting in univalents during metaphase I, as well as anaphase I laggards, resulting in an unequal segregation of chromosomes. A third specimen, *Spies* 1667, exhibited an unsynchronized chromosome segregation during anaphase I (the chromosomes in one part of the metaphase plate had already segregated to the polar region before segregation started in another part of the metaphase plate), as well as a number (up to five) of chromosome bridges during anaphase I. The pentaploid specimen, *Spies* 1698 (Figure 2a & b), had 8–14 laggards during anaphase I and a large number of micronuclei were observed in cells which were in the telophase I stage;

6, *Paspalum urvillei* (*Spies* 1612): univalents were observed in some of the cells studied (Figure 2c & d);

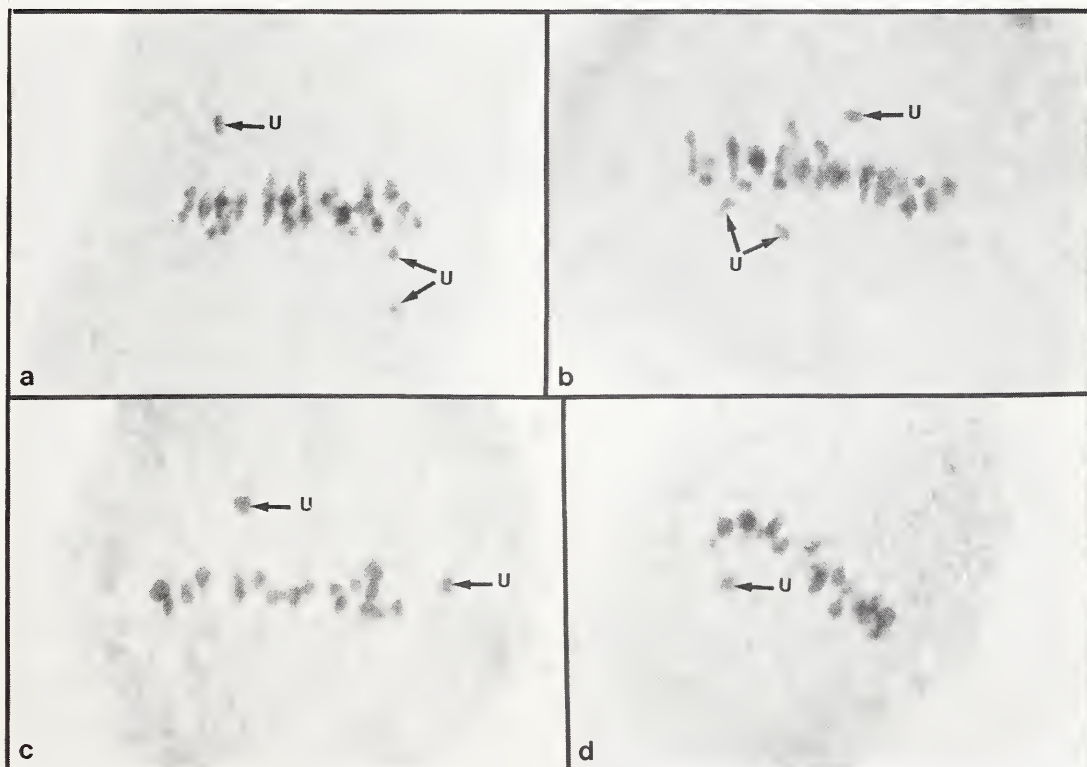


FIGURE 2.—Meiotic cells: a & b, *Paspalum dilatatum*, *Spies* 1698; c & d, *Paspalum urvillei*, *Spies* 1612. a & b, metaphase I showing univalents (U); c & d, metaphase I showing univalents (U). Scale: $\times 2900$.

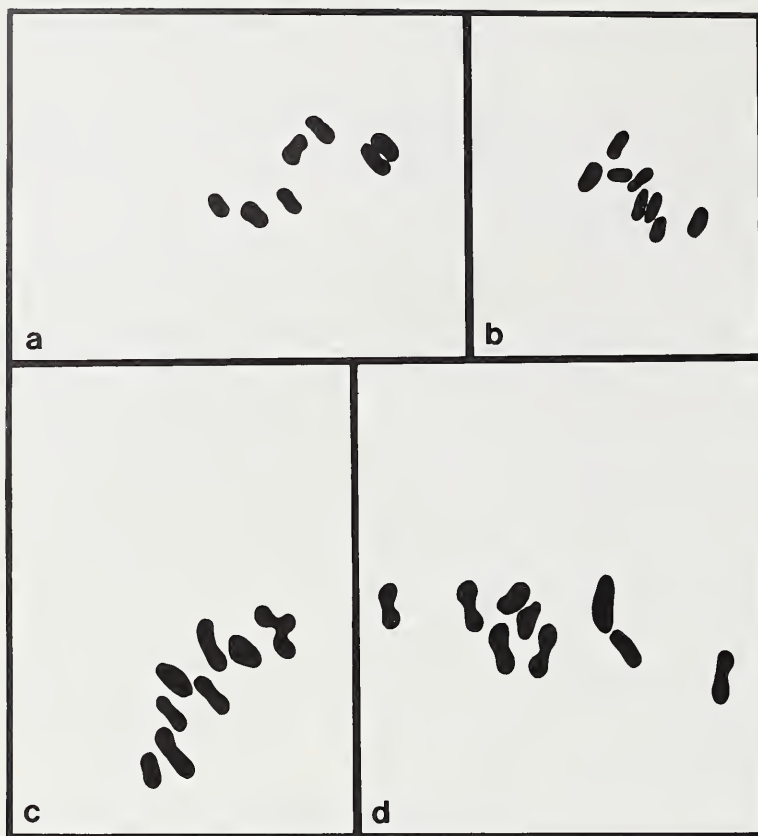


FIGURE 3.—Diakinesis in *Pennisetum macrourum*, Spies 1579: a, seven bivalents; b & c, nine bivalents; d, eight bivalents. Scale: $\times 2900$.

7, *Paspalum* sp. (Spies 1444a): in contrast to the other specimens of this genus, this one was relatively normal. Only one abnormal anaphase I cell with seven laggards was observed;

8, *Cenchrus ciliaris* (Spies 1650): this aneuploid specimen had from one to seven univalents during metaphase I. No chromosome laggards were observed during anaphase I. The somatic chromosome number of 29 may imply chromosome loss in a tetraploid specimen, hence the univalents. However, further investigation is necessary before such a conclusion can be reached;

9, *Stipa dregeana* (Spies 1693): up to five chromosome bridges were observed during anaphase I.

Apart from the meiotic abnormalities observed during this study, the possible occurrence of B-chromosomes obscured the easy interpretation of some results. In one *Pennisetum macrourum* specimen, Spies 1579, 37,5 % of the cells studied had seven bivalents, 33,3 % had eight bivalents and 29,2 % had nine bivalents (Figure 3). Since the chromosomes in all cells were well stained and good spreading was obtained, it was impossible to confuse a bivalent with a univalent. Our only explanation for this phenomenon is that this *P. macrourum* specimen had 14 somatic chromosomes that form 7 bivalents during meiosis and that 0–4 B-chromosomes, which mimic euchromosome meiotic behaviour, were present.

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African plants. 2. *Bothalia* 16: 269–270.

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CHROMOSOME STUDIES ON AFRICAN PLANTS. 4.

The presentation of chromosome numbers in this report conforms with the format described in the first publications of this series (Spies & Du Plessis 1986 a & b).

POACEAE

Aristideae

Aristida congesta Roem. & Schult. subsp. *congesta*: **n = 22.**

TRANSVAAL.—2530 (Lydenburg): 14 km from Boshhoek to Diep-geset (–AC), *Spies* 1537.

Eragrostideae

Eragrostis barbinodis Hack.: **n = 25.**

TRANSVAAL.—2528 (Pretoria): 35 km from Warmbaths to Pretoria (–AB), *Spies* 2046.

Eragrostis curvula (Schrud.) Nees: **n = 20, 30, 40.**

TRANSVAAL.—2430 (Pilgrim's Rest): 18 km from turnoff on Lydenburg-Ohrigstad road to Pilgrim's Rest (–DC), *Spies* 1557 (n = 40), 1559 (n = 20). 2530 (Lydenburg): 10 km from Boshhoek to Bufelsvlei (–AC), *Spies* 1526 (n = 30).

CAPE.—3224 (Graaff-Reinet): 23 km from Pearston to Graaff-Reinet (–BD), *Spies* 1139 (n = 20).

Eragrostis lehmanniana Nees: **n = 20, 30.**

CAPE.—3224 (Graaff-Reinet): 2 km from Jansenville to Kirkwood (–DD), *Spies* 1099 (n = 20). 3225 (Somerset East): 35 km from Somerset East to Pearston (–CA), *Spies* 1135 (n = 20). 3325 (Port Elizabeth): 1 km from Lake Mentz to Waterford (–AA), *Spies* 1083 (n = 30), 1094 (n = 20).

Eragrostis plana Nees: **n = 10.**

TRANSVAAL.—2530 (Lydenburg): 11 km from Goede Hoop to Lydenburg (–AB), *Spies* 1506.

CAPE.—3227 (Stutterheim): Kabusi Forest (–CB), *Spies* 1697.

Eragrostis planiculmis Nees: **n = 21.**

TRANSVAAL.—2530 (Lydenburg): 31 km from Lydenburg to Roosenekal (–AB), *Spies* 1620.

Eragrostis superba Peyr.: **n = 20, 40.**

TRANSVAAL.—2529 (Witbank): 67 km from Lydenburg to Roosenekal (–BB), *Spies* 1625 (n = 40).

O.F.S.—2925 (Jagersfontein): near Perdeberg (–AA), *Spies* 2003 (n = 20).

Eragrostis trichophora Coss. & Dur.: **n = 30.**

TRANSVAAL.—2528 (Pretoria): near Sphinx Station (–CA), *Spies* 2031.

Pogonarthria squarrosa (Roem. & Schult.) Pilg.: **n = 40.**

TRANSVAAL.—2528 (Pretoria): near Sphinx Station (–CA), *Spies* 2020.

Sporobolus africanus (Poir.) Robyns & Tournay: **n = 30.**

CAPE.—3225 (Somerset East): 7 km from Somerset East to Pearston (–CB), *Spies* 1129. 3228 (Butterworth): near Sunrise-On-Sea (–CC), *Spies* 1639.

Sporobolus pectinatus Hack.: **n = 20.**

TRANSVAAL.—2530 (Lydenburg): 13 km from Boshhoek to Bufelsvlei (–AC), *Spies* 1530.

Cynodonteae

Chloris gayana Kunth: **n = 10.**

CAPE.—3228 (Butterworth): near Sunrise-On-Sea (–CC), *Spies* 1660.

Chloris virgata Swartz: **n = 10.**

TRANSVAAL.—2528 (Pretoria): near Sphinx Station (–CA), *Spies* 2021.

O.F.S.—2925 (Jagersfontein): near Perdeberg (–AA), *Spies* 2005.

DISCUSSION

These chromosome numbers conform, in most instances, with the numbers for either the species itself or for other species in the same genus, given in the chromosome atlases of Darlington & Wylie (1955), Ornduff (1967–1969), Fedorov (1969), Moore, R. J. (1970–1977), Moore, D. M. (1982) and Goldblatt (1981 & 1984). The only exception was *Eragrostis planiculmis* with $2n = 42$ instead of a multiple of 10 expected in the Eragrostideae. Since 21 bivalents were observed in every cell studied, it is concluded that this specimen, *Spies* 1620, represents an aneuploid form of *E. planiculmis* with $2n = 4x + 2 = 42$.

Meiotic chromosome pairing was normal in most specimens studied.

Two univalents were observed in every cell of a diploid *Eragrostis plana* specimen, *Spies* 1506. This asynapsis of a chromosome pair may perhaps be attributed to hybridization.

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PERFORMANCE OF A LABORATORY-CONSTRUCTED ANEMOMETER UNDER SUMMER FIELD CONDITIONS ON A MOUNTAIN FYNBOS EXPERIMENTAL SITE

The consumer-oriented electronics industry has developed extremely rapidly over the past decade and has provided many beneficial side-effects for experimental scientists. A development of particular interest to environmental researchers is the advent of a new generation of relatively inexpensive solid-state data-loggers. This type of apparatus, which uses the same technology as that of the popular digital microprocessor industry, makes continuous monitoring of environmental parameters at remote sites feasible for even modestly funded studies. The analogue sensors needed to provide the logging device with input information, however, do not usually arise from similar high-volume production lines, and very often constitute the most costly part of any data monitoring system. This article intends to illustrate the idea that inexpensive, laboratory-constructed transducers can play an important role in optimizing the potential benefits of modern data-logging equipment.

During 1985, an experimental study plot was established in an area of natural mountain fynbos at an altitude of 375 m in the Highlands State Forest Reserve in the south-western Cape, on a site which had been cleared by burning in February of that year. Since the wind, especially the forceful summer 'south-easter', is a dominant feature of the regional climate, and one to which the vegetation is probably adapted in many respects (see Boucher 1972), it was decided to dedicate one channel of an on-site logger to measuring wind-speed at the site. The most economical and convenient means of achieving this was to construct a three-cup anemometer similar to that described by Unwin (1980), but using a small 3 VDC electric motor as a voltage generator in place of an electronic pulse counter. Investment in the instrument comprised less than R15,00 in component parts and approximately one working-day for assembly and calibration, whereas the cost of an imported commercial anemometer of similar design (Didcot DWR/201G) was cited as more than R2 000,00 at the time of writing.

The cup wheel was constructed from half table tennis balls, 2 mm brazing rod, microjet irrigation fittings, and epoxy resin (see Figure 4). Output from this generator was adjusted via a half-bridge resistance circuit to provide the logger with a signal in the correct range of 0 to 2 000 mVDC. Although it is reported (Woodward & Sheehy 1983) that anemometers using this principle of signal generation have a relatively high detection threshold (up to 2 m.s⁻¹), this shortcoming was not considered a hindrance to the measurement of maxima, and the

approximation of mean windspeeds for the expected seasonal windy conditions. The length of the arm (47 mm) relative to the cup radius (17 mm) was close to the ratio of 2,5 recognized as a reasonable compromise between sensitivity and linear response (see Grace 1977). In the field, the device was mounted with the cups 1,5 m above the ground.

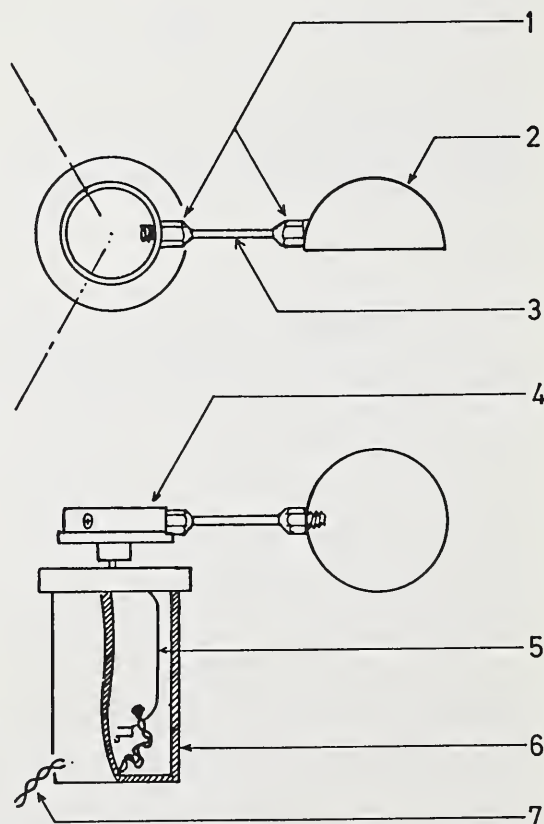


FIGURE 4.—Construction of the D.C. generator anemometer. Component parts were assembled as indicated in the above sketch, with slow-setting epoxy resin as a joining and sealing medium. The parts labelled are: 1, microjet irrigation couplers; 2, half table tennis ball; 3, brazing rod; 4, plastic vial lid; 5, electric motor; 6, plastic film cannister; and 7, electric leads to monitoring circuitry. Scale is provided by the table tennis ball which has a diameter of 34 mm.

The instrument was calibrated on a windless day by mounting it 0,5 m above the roof of a car, and driving at constant speeds between 20 and 80 km.h⁻¹ (5,6 and 22,2 m.s⁻¹) while measuring the output on a digital voltmeter (Fluke, model 73). Accuracy ($\pm 5\%$) of the car's speedometer was checked within the calibration range by timing displacement over measured distances. Further comparisons were made *in situ* in the field with an adjacently mounted totalizing anemometer (S.I.A.P., model 1220) over 30-minute periods on a windy day (Figure 5). This latter set of measurements implied a reliable detection threshold of approximately 2 m.s⁻¹.

During the measurement period (November 15, 1985 to March 13, 1986), output from the anemometer was measured once per minute, and processed by inbuilt data-logger software to provide a mean windspeed value for every three-hour interval, as well as the maximum single value recorded during each day. Information is summarized in Figures 6 & 7 for the full period, a time of year when the south-east wind is common. From Figure 6 it can be seen that on only one day during the trial period did air movement remain below the reliable detection threshold for the full 24-hour period, while an overall maximum windspeed of 16,1 m.s⁻¹ was recorded on November 18. The three-hour mean values have been combined for the whole measurement period, and plotted in Figure 7 to indicate the diurnal pattern of air movement. The site may not be subject to the full force of the south-easter, as it is approximately 75 to 125 m lower than a ridge two kilometres distant to the south and south-east. Records of windspeed at D. F. Malan Airport indicate that gusts of 28 m.s⁻¹ may be experienced on the Cape Flats between November and March (Weather Bureau 1960).

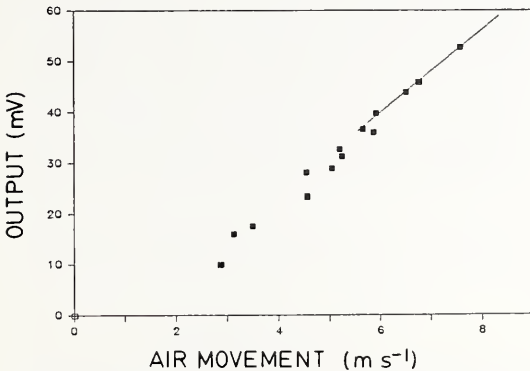


FIGURE 5.—Calibration of the D.C. generator anemometer. The solid line ($Y = 8.121X - 8.895; r^2 = 0.9997$) represents in part the calibration of the device against a car speedometer for five values between 5,6 and 22,2 m.s⁻¹ (values beyond 8 m.s⁻¹ are not shown). Solid points compare mean output to mean windspeed as measured at the study site by an adjacently mounted totalizing anemometer over 30-minute periods.

Although a quantitative measurement of accuracy has not been made on the instrument, both the linearity of the calibration and the favourable comparison with a commercial anemometer suggest that the recorded measurements of air movement at the study site are accurate within the limits outlined above. Other more sensitive devices of sophisticated design for windspeed measure-

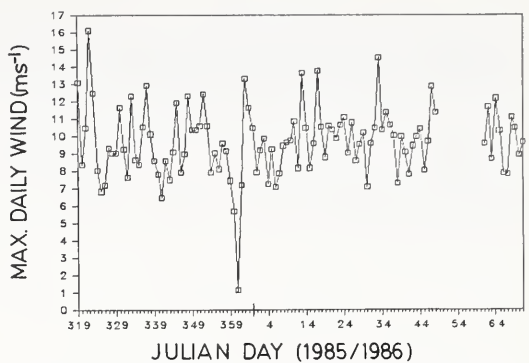


FIGURE 6.—Maximum daily windspeeds measured at the Highlands study-site. The gap starting at day 49 (Feb. 18, 1986) indicates a period of missing data owing to a problem with programmable memory space in the recording device.

ment (see Rosenberg 1974) can be constructed for interfacing with a data-logger. Practical designs for transducers to measure other environmental parameters are also readily available from the literature—see Chapter 8 of Woodward & Sheehy (1983) for a useful list of references. Apart from their benefit as instruments of opportunistic data capture, relatively cheap laboratory-constructed transducers can be left unattended with less anxiety at remote stations where pervasive human vandalism is frequently a threat.

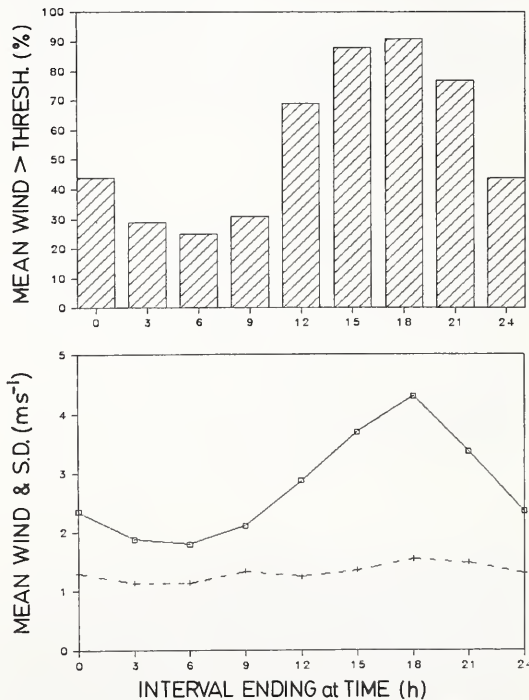


FIGURE 7.—Diurnal pattern of air movement at the Highlands study-site. The histogram above shows the ratio of days in the measurement period when the mean measured wind-speed during the relevant time interval was above 2 m.s⁻¹. Below is the overall mean windspeed, including calms, for each time interval (solid line), and the associated standard deviation of each (broken line).

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G. W. DAVIS

REVIEW OF THE WORK OF THE BOTANICAL RESEARCH INSTITUTE, 1985/86

1st April 1985–31st March 1986

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INTRODUCTION

Good progress has been made with research and the publications of the Institute reflect this very clearly. Nevertheless, there is a steady erosion of available research funds due to minimal growth and continuing inflation. The unfilled research posts now constitute nearly 11 % of the total, a situation which may be partially responsible for a drop in the total number of individual research papers published this year. The production of journals has, however, remained very stable and the publication of two *Memoirs*, one volume of *Palaeoflora*, one volume and two parts of volumes of the *Flora of southern Africa* is remarkable progress under present circumstances.

The increasing demand for botanical information and plant identifications is reflected in the 28 000 plant identifications done last year. This has, however, meant that most of the professional staff in the herbaria have not had any time for research, a situation which is severely affecting their careers. In spite of an increase in demand for plant identifications of approximately 100 % over a period of 20 years which has been met by increasing efficiency, the herbarium staff complement has not been expanded for 20 years and an intolerable situation has arisen where demands can no longer be met effectively.

The initiatives being taken in connection with pasture research have opened new perspectives also in botanical research. These are now being actively pursued.

HERBARIUM DIVISION

Due to serious understaffing problems, the four herbaria of the Institute are finding it increasingly difficult to cope with the existing workload. This is affecting all three of the major areas of performance, namely, curation, research and information services. This has resulted largely because the staff complement has remained static for more than 20 years while, in the last seven years alone, the workload has increased by over 220 %. Figures for the National Herbarium show that during this period the number of revisions incorporated each year has increased by 348 %, exchanges with other herbaria by 330 %, accessions by 57 %, identifications by 40 %, registered projects by 400 % and the maintenance and updating of PRECIS by over 300 %. Every effort is being made to try and deal with the problems being experienced.

National Herbarium, Pretoria (PRE)

Curation

Approximately 140 scientific journals were scanned for taxonomic and nomenclatural changes covering the FSA-region. Statistics available for the monocotyledon families show that during the year 530 new names were adopted, extracted from 41 publications. Of these, 111 were new species.

The updating of the PRECIS databank continued with $\pm 7\ 400$ specimens having undergone name changes and 18 400 specimens having had their grid references added or corrected. Other miscellaneous changes affected 3 620 specimens.

Distribution records were significantly extended for 63 taxa, mostly at the provincial level. These included a number of new records for southern Africa largely involving the mosses and lichens.

Computerization

A multi-user Burroughs computer was purchased. This will be used in the herbarium as a management, curatorial and research tool and should significantly boost efficiency and productivity. Mr T. H. Arnold is currently designing various applications to improve the handling of plant identifications, loans and exchanges as well as the printing of specimen labels. It is also planned to use the computer to selectively regulate specimen accessions into the herbarium. This new computer will be directly linked by modem to the B7900 mainframe housing the PRECIS databank.

Accommodation

Electrification of the north side of the herbarium wings is complete. No progress has been made with the installation of three additional working bays on the south side of each wing. Plans have been submitted for a new SEM room and for a two-room prefabricated building in the eastern courtyard to house the four new plant driers and the deep-freezers used to decontaminate specimens. No new herbarium cabinets were purchased. Fire protection and insect proofing of the herbarium is due to start towards the end of 1986. Alterations costing $\pm R1\ 000\ 000$ will take place over a 8–10 month period and will seriously affect all activities in the herbarium.

Collecting expeditions

These include trips to Zululand (general collecting and Poaceae), south-east OFS and northern Cape (Poaceae, general collecting and Bryophyta), Natal (*Vigna*), eastern Transvaal (*Transvaal wild flowers* facet), Natal Drakensberg and southern Cape (lichens).

Research and related activities

The family Polygonaceae (G. Germishuizen). The genera *Polygonum*, *Bilderdykia* and *Reynoutria* have been written up in FSA format and submitted to the editor. Revisions of *Oxygonum* and *Rumex* are progressing well with two new *Oxygonum* taxa having been prepared for publication.

Revision of Riccia (Hepaticae) (S. M. Perold). This facet is nearing completion. Seven papers were prepared and submitted for publication. These include six new species as well as a new section and subgenus.

Revision of Vigna (Fabaceae) (B. J. Pienaar). SEM studies of leaf surfaces produced no significant characters of taxonomic value. Two distinct groups were recognized based on keel orientation. The structure and location of glands was also useful in the grouping of taxa.

Revision of Carex (Cyperaceae) (C. Reid). Work on this genus was recently started and to date has been confined to a study of PRE material. A number of problem taxa have been identified as well as four possibly new species.

Contributions to the moss flora (J. van Rooy). Work on the family Bryaceae for the 2nd fascicle of Bryophyta of the *Flora of southern Africa* was completed. As soon as all the illustrations have been prepared, this fascicle will be submitted for publication. A revision of the family Orthotrichaceae (6 genera, 27 species) was started for the 3rd fascicle.

Transvaal wild flowers. Vol. 2 (G. Germishuizen). Eighty species (13 % of total) have been illustrated by the artist Mrs A. Fabian. The text for half of these has been prepared.

Plant species and synonym list (various contributors). Work on Part 2 of the second edition was completed. This covers all dicotyledon families. The manuscript is awaiting checking before being submitted for publication.

Research support

Scanning electron microscope (S. M. Perold). 1968 micrographs were prepared for various BRI and outside workers. These include—*Ehrharta* leaf surfaces, lemmas of *Panicum* and *Digitaria*, Cucurbitaceae fruit and seed surfaces, lichen thalli, *Vigna* inflorescence and leaf surfaces, fossil leaf cuticles, *Riccia* spores and thalli, fern spores and *Euphorbia* leaf and seed surfaces. Dr H. F. Glen also continued his investigation of *Aloe* leaf surfaces.

Determination of priority collecting areas (various contributors). The number of species and specimens per ¼ degree square was extracted from the PRECIS databank and used to plot species and specimen frequency distribution maps for southern Africa. A number of fairly well defined areas, which are poorly represented by collec-

tions in the National Herbarium, were identified from the maps.

Based on this information, expeditions were undertaken to fifteen ¼ degree squares in three of the areas (in Natal, south-east OFS and central Cape) to test the extent to which intensive collecting could improve the representation of taxa in the PRE Herbarium. In 14 of the 15 squares the holdings were increased significantly (from 3,2- to more than 10-fold).

Special collecting vehicle (M. D. Panagos). A Nissan Ekonovan is being fitted as a special collecting vehicle. A two-way radio has been purchased and a special roof-rack designed and fitted to carry 12 plant presses. The roof-rack will facilitate rapid drying of plant material while the vehicle is moving. A roll-up awning has been fitted to shelter workers during unfavourable weather. Fitting of the interior of the vehicle is still at the design stage. Figure 1.



FIGURE 1.—A Nissan Ekonovan which has been fitted for collecting. The roof-rack carries 12 plant presses. The roll-up awning shelters workers during unfavourable weather.

Collecting Poaceae for the National Herbarium (L. Fish). A single collecting trip was undertaken to poorly represented areas of the OFS and north-eastern Cape. 169 specimens representing 156 species were collected. For both species and specimens, representation in the PRE herbarium was increased significantly (more than 15-fold) for four of the five ¼ degree squares sampled. Over 800 duplicates were collected for distribution to herbaria worldwide.

Expansion of the fruit and seed collection (E. Retief). This has been contributed to largely by material collected during fieldwork for other facets. The fruit collection was extended by 392 to 4 335 collections. The seed collection was extended by 591 to 4 003 collections.

Publications. Fourteen articles appeared in various local as well as overseas publications (see Publications by the staff). A further 32 articles are in press. The plant names in Acocks's *Veld types of South Africa* were updated by Mrs E. van Hoepen in preparation for the publication of the next edition of this work.

Contributions to outside publications. Various members of the division contributed to the Ciba Geigy book *Weeds of crops and gardens in southern Africa* (published 1985) and to the Auriol Batten book *Flowers of southern Africa* by checking the texts.

Plant identification services. 16 248 specimens were identified for officers of the Institute, various State

Departments and Provincial Administrations, universities and neighbouring states. In addition, identifications for visitors numbered 925. Enquiries received by telephone totalled 1 136. New accessions to the herbarium numbered 20 779. Because of a shortage of typists, the backlog with the typing of specimen labels remains at 12 months.

Loans and exchanges. 67 loans (comprising 7 164 specimens) were sent out and 45 loans (2 910 specimens) returned. The total number of outstanding loans is 288 (35 069 specimens).

Natal Herbarium, Durban (NH)

With Mr B. D. Schrire transferred to the Royal Botanic Gardens, Kew, London, as the South African Liaison Officer, Mrs M. Jordaan was appointed as curator of the herbarium and officer in charge of the unit. Besides administering the unit, she also continued to be responsible for the bulk of identifications received, assisted by Mr A. M. Ngwenya and Mr C. N. Buthelezi.

During this period, it was possible to maintain a good service record despite the serious manpower shortage. This includes 4 606 plant identifications, assisting 409 visitors, handling 729 telephone enquiries, dispatching 1 272 specimens out on loan and accessioning 2 765 specimens.

Considerable time was spent sorting and refining taxa in the herbarium and a start was made to remove specimens of western Cape taxa. To date, 370 monocotyledon specimens have been sent to the National Herbarium and 233 to the Stellenbosch Herbarium. When time permitted, studies in the Celastraceae and *Cussonia* were continued.

Plans were submitted to have the poorly utilized room adjacent to the herbarium insect-proofed and converted into a mounting and parcelling room.

Government Herbarium, Grahamstown (GRA)

The staff are now well settled into their new quarters with all activities functioning normally.

There has been an overall increase in services with 3 241 plant specimens identified, assistance given to 1 109 visitors, 494 telephone enquiries dealt with and 13 loans (1 185 specimens) sent out.

A special effort was made to improve the quality of the collections by scanning through covers, renaming misidentified specimens and generally sorting taxa into more homogeneous groups. Some 253 genera were examined and the names of 125 specimens updated.

Mrs Rei Hart was appointed to a part-time post, funded by the Pocock bequest to the Albany Museum. She will curate the Pocock Marine algae collection which last received attention in 1969. To date, she has systematically examined the green and brown algae and has mounted, sorted and accessioned all the material in 74 genera.

Mr Neil Abrahams continued giving voluntary assistance in the herbarium by helping with the labelling and mounting of specimens.

The block clearing of alien plants on the Grahamstown Nature Reserve remains an endless problem. This work continued throughout the year with the reserve curator assisted by the Herbarium Laboratory Assistant for a period of five months. Despite this, the problem is still not under control.

Government Herbarium, Stellenbosch (STE)

Mr R. O. Moffett took over from Mrs C. M. van Wyk (who was transferred to PRE) as curator of the herbarium.

A total of 2 995 specimens was identified, 312 visitors were assisted, telephone enquiries numbered 332, accessions into the herbarium totalled 4 810 and 904 specimens were sent out on loan. Because of the staff shortage and the identification backlog that existed, an additional 636 specimens were sent to PRE where they were identified by Mrs Van Wyk. The naming backlog has been greatly reduced.

Four collecting trips were undertaken to the following areas—De Hoop, Sutherland, Barrydale (Langeberge) and to the southern Karoo. A total of 755 collections was made.

Mr Moffett continued with his study of the genus *Rhus* which is now largely completed. A paper titled 'A SEM study of the leaf of *Rhus* species in southern Africa' was presented at the SAAB Congress in Umtata, Transkei.

FLORA RESEARCH DIVISION

Flora of southern Africa (FSA)

The FSA subproject has had impact outside the Institute in several ways. The Department provided extra support through awarding a research contract to the University of Cape Town, for the Orchidaceae volume; following the untimely death of Prof. E. A. Schelpe, the contract was taken up by Prof. A. V. Hall. The fourth meeting of the FSA working group was held during the Congress of the South African Association of Botanists in January 1986. News of interest to FSA contributors was circulated in *Forum Botanicum*, the newsletter of SAAB.

Three *Flora* fascicles were published. Vol. 4,2 by Mrs A. A. Obermeyer (Maue), who has recently retired, deals with the families Xyridaceae, Eriocaulaceae, Comelinaceae, Pontederiaceae and Juncaceae. The fascicle covers 17 genera and 106 species in the five families. Vol. 14 by H. R. Tölken, formerly of the BRI and now at the herbarium in Adelaide, Australia, covers the family Crassulaceae, with six genera and 215 species (345 species and infraspecific taxa). Vol. 31,1,2 by C. Puff covers the tribes Paederieae, Anthospermeae and Rubieae in the Rubiaceae, comprising eight genera and 74 species. Dr Puff, of the Institute for Botany at the University of Vienna, completed the research on a fellowship from the Department.

The *List of species of southern African plants*, Edn 2, Part 1, covering cryptogams, gymnosperms and monocots was published, and Part 2, covering dicots, is nearly complete. The *List of species* is a precursor to the FSA that presents up-to-date coverage of all taxa at increasing levels of approximation, and future editions will contain additional information, such as distribution, conservation status and life form.

Institute staff members, and outside contributors on contract made the following progress with research facets for the FSA:

Lichens: Prof. O. Almborn of Lund, Sweden, has increased the list of potential contributors to the lichen volume to 33, and has made a formal division of the work into fascicles.

Bryophyta: The genus *Bryum* was completed by Mr J. van Rooy, and Fascicle 2, with Dr R. E. Magill of the Missouri Botanical Garden as senior author, is almost ready for the press.

Vol. 2: Poaceae—Oryzoideae, Centostecoideae and Bambusoideae. The draft for *Ehrharta* was completed by Dr G. E. Gibbs Russell, but a number of type specimens must still be seen. All types have been examined for *Oryza*, *Leersia*, *Prophytochloa* and *Megastachya*.

Vol. 4: Restionaceae. Dr H. P. Linder has been on leave travelling and collecting plants in tropical Africa for a year: therefore little work has been done. However, a conspectus of 318 species, arranged according to his own generic classification, was published in *Bothalia* 15, 3 & 4 (1985).

Vol. 5: Liliaceae—Aloinae—*Aloe*. The FSA manuscript for *Aloe* by Dr H. F. Glen and Mr D. S. Hardy is nearing completion. Dr Glen has carried out an extensive survey of leaf epidermal types using the scanning electron microscope, assisted by Mrs S. Perold.

Vol. 8: Orchidaceae. Prof. A. V. Hall has taken over the contract on the death of Prof. E. A. Schelpe. Thirteen genera were completed by Mrs N. C. Anthony, who resigned in July 1985. Of the remaining work to be done, Mrs J. Stewart, of the Herbarium, Royal Botanic Gardens, Kew, has agreed to contribute 23 genera, and Miss K. L. Immelman will contribute *Holothrix*. Seventeen genera, comprising about 65 species, still require attention.

Vol. 9: Salicaceae, Fagaceae, Urticaceae and Piperaceae. FSA manuscripts have been prepared for all genera, and only a few type specimens are needed before the work can be finalized. The work on Urticaceae has been done in collaboration with Dr I. Friis of the Botanical Museum and Herbarium, Copenhagen.

Vol. 11: Mesembryanthemaceae. A treatment of *Astridia*, *Acrodon* and *Ebracteola* is in press in *Bothalia*.

Vol. 16: Fabaceae—Desmodieae. Mr B. D. Schrire's account of the tribe is being prepared for *Bothalia*. The FSA fascicle of which it forms a part will not appear until other genera have been completed.

Fabaceae—Millettiae. Mr Schrire has studied generic limits between *Mundulea* and *Tephrosia*, and has produced a conspectus of the species and species complexes in *Tephrosia* subgenus *Barbistyla*, which will be published in *Bothalia* to serve as an aid to identification until the FSA treatment is complete.

Vol. 25: Ericaceae. Mr E. G. H. Oliver has continued studies in the 'minor genera', concentrating on *Sympieza*, *Ericinella*, *Coilostigma*, *Blaeria* and *Anomalanthus*. Monographic treatments of *Ericinella* and *Coilostigma* are in press in *Bothalia*, but future work will be written in FSA format.

Vol. 30: Acanthaceae—*Justicia*. Miss Immelman's completed FSA manuscript is with the editor, and

awaits contributions from researchers from other institutions before the fascicle can be published.

Pretoria Flora

The text of Asclepiadaceae and Poaceae was completed, translated into Afrikaans and typeset except for 10 pages of the Afrikaans text of Poaceae. Some 60 species of Asteraceae were written up. They were keyed out in nine major groups. Three preliminary lists were compiled and put on word processor memory: 1, a list of scientific names in which families are alphabetically arranged and in which genera are again alphabetically arranged within their families; 2, a list in which families are arranged in the sequence in which they appear in the work, with taxa alphabetically arranged under their family; 3, a list of vernacular names.

Altogether 303 English and 275 Afrikaans pages have now been typeset making a total of 578. Some 1 781 species have so far been dealt with.

Palaeoflora of southern Africa

The *Prodromus of South African Megafloras, Devonian to Lower Cretaceous*, by Drs J. M. and H. M. Anderson was published. It covers all plant fossils known for southern Africa during the Pangaea period. Eighteen different 'floras' dominated at different times, and each flora is related to major geological events such as glaciation. The Andersons are now preparing the second in the Molteno Formation series, dealing with all the gymnosperms except *Dicroidium*, which was published in Volume 1.

Liaison Officer, Kew

Mr B. D. Schrire assumed duty as the new Liaison Officer. He has continued to provide information about taxonomic and related subjects to researchers on the southern African flora, and to pursue his research in Fabaceae. He has developed a particular interest in taxon databases, and is co-operating in the International Legume Database as the person responsible for Indigoferaeae.

DATA SUBDIVISION

The Subdivision co-ordinates the work of the Institute on the Department's Burroughs 7900 mainframe computer. Two large systems maintained on this computer are the taxonomic database PRECIS and the ecological database PHYTOTAB. The Subdivision also maintains a Hewlett-Packard 9845B microcomputer, which was heavily used in the past. However, the present trend towards personal computers in each Division has lessened the use of the eight-year-old Hewlett-Packard.

PRECIS is managed by Mrs J. C. Mogford, and now consists of four components. Specimen-PRECIS contains herbarium specimen label data in 24 data fields for 615 000 specimens in PRE herbarium; taxon-PRECIS contains recent useful literature, synonymy, status as naturalized alien, and status of current taxonomic research for the 24 000 plant taxa in southern Africa; nomenclature-PRECIS has begun as a prototype for Poaceae, to be developed further when staff is available; and curatorial-PRECIS is to be developed on a Burroughs 25 microcomputer network to link information for specimen-PRECIS to the curatorial and administrative needs of the Herbarium Division.

PHYTOTAB, managed by Mr M. D. Panagos, has entered a phase of adding data from published ecological surveys, and 37 such datasets are now in the system. Fourteen additional datasets are being manipulated to analyse data for current research facets, and three of these are generating keys for vegetative identification of plant species in the areas of the surveys. The keys are designed for plants of the Waterberg, for grasses of the Amersfoort area, and for plant families of South West Africa/Namibia.

Smaller systems maintained on the Burroughs 7900 include the Garden Records system, developed by Mrs B. C. de Wet for data about all the plants in the botanical garden, and PHOTOS, developed by Miss A. P. Backer to record data about photographic vegetation records for the Vegetation Ecology Division.

BIOSYSTEMATICS DIVISION

Pending further developments, this new Division, with an effective staff of three, devoted itself largely to the scientific and technical editing of the publications of the Institute. Mrs E. P. du Plessis, who was recently appointed, is doing all the translating into Afrikaans required by the Institute, including that for *Flowering Plants of Africa* and *Pretoria Flora*.

Bothalia

In future two separate numbers of this journal will be published, one in the middle and one at the end of the year. A new guide to authors was made available and will be published in Vol. 16,1. It agrees essentially with that of the *South African Journal of Botany* except for certain aspects of specimen citation.

Vol. 15, 3 & 4 was published; 16,1 is in press and 16,2 and the index to Vol. 15 are at an advanced stage of editing.

Flora of southern Africa (FSA)

One volume and two parts of volumes were published (See Flora Research Division).

The following are in press: Pteridophyta and Vol. 18,3 with Simaroubaceae, Burseraceae, Ptaeroxylaceae, Meliaceae and Malpighiaceae.

A new edition of the guide for authors was compiled.

Flowering Plants of Africa (FPA)

Vol. 48, 3 & 4 was published and 49, 1 & 2 is in press.

Memoirs of the Botanical Survey of South Africa

All numbers of this series were produced in camera-ready form. The following were published: No. 50 *A classification of the mountain vegetation of the Fynbos Biome* (B. M. Campbell); No. 51 *List of species of southern African plants*. Edn 2. Part 1 (G. E. Gibbs Russell *et al.*).

The following numbers are in press: No. 52 *A plant ecological bibliography and thesaurus for southern Africa up to 1975* (A. P. Backer *et al.*); No. 53 *A catalogue of problem plants in southern Africa incorporating the National weed list of South Africa* (M. J. Wells *et*

al.); No. 54 *Biomes of southern Africa—an objective categorization* (M. C. Rutherford & R. H. Westfall).

No. 55 *Barrier plants of southern Africa* (L. Henderson) is at an advanced stage of editing and a third edition of *Veld types of South Africa* (J. P. H. Acocks) is in preparation.

Palaeoflora of southern Africa

Prodromus of South African megaflores, Devonian to Lower Cretaceous by J. M. & H. M. Anderson was published by A. A. Balkema.

Flowers of southern Africa by Auriol Batten

Assistance was given with the editing and proof-reading of this work which is scheduled to appear by the middle of 1986.

PLANT STRUCTURE AND FUNCTION DIVISION

Dr J. J. Spies was awarded a Ph.D. degree for his work on the cytogenetics of *Lantana camara*, a sophisticated and detailed study with important practical implications. Mrs A. Marks left us during October and Miss A. Jonker joined the cytogenetics team in January as a Research Technician.

Comparative grass leaf anatomy

Dr R. P. Ellis attended the XI AETFAT meeting in St Louis, Missouri, where he took part in a symposium on modern systematic studies in African botany. His paper dealt with the leaf anatomy and systematics of the African grasses, with special attention being paid to the genus *Panicum*. During the year attention was given to the genus *Ehrharta*, which exhibits unusual anatomical variation and appears to be in need of taxonomic re-evaluation.

Cytogenetics of the Poaceae

Dr Spies and his team are making excellent progress with the collection of material and 275 species from 115 genera have been transplanted to the Pretoria National Botanical Garden. From each of these accessions, root tips are collected for mitosis squashes, anthers for meiosis squashes, young embryo sacs for developmental studies and seed is fixed for studies of the embryo formula. This work holds exciting prospects for the future.

VEGETATION ECOLOGY DIVISION

The function of the Vegetation Ecology Division is to study the vegetation of South Africa and its ecological relations. This work involves three main aspects: the identification, description, classification and mapping of the various kinds of vegetation; study of the ecological relationships between different kinds of vegetation—with one another and with the environment—and of the various processes and mechanisms that determine the behaviour of plant communities; and the application of such ecological knowledge to the management and utilization of vegetational resources.

Transvaal bushveld studies

The area designated for research on the vegetation ecology of Sour Bushveld in the Transvaal Waterberg

was stratified by Mr R. H. Westfall for sampling efficiency. A scale-related, vegetation-enhanced satellite-imagery method was developed for this purpose and should be of great interest for determining spatial patterns of vegetation and environment. Predictive expressions of species-area relation were established for determining subsample size. The initial 14 relevés sampled substantiate the validity of both the species-area expressions and the stratification.

Transvaal forest survey

The results of the study of the vegetation ecology and environment in the Sabie area were successfully submitted by Mr G. B. Deall as an M.Sc. thesis. These results together with follow-up work are being prepared for publication.

Coastal studies

Manuscripts on the dune vegetation between Richards Bay and the Mlalazi Lagoon and on the dry coastal ecosystems of the east coast of South Africa were finalized by Dr P. J. Weisser for publication. He has also prepared a report on the vegetation of the Mzingazi Lake for the CSIR, and has finalized detailed research planning for the study of the coastal-dune area between Kosi Bay and Sodwana.

Mr M. G. O'Callaghan has analysed vegetation data from in and around the estuaries entering False Bay. Three aquatic, semi-aquatic and 15 terrestrial communities were recognized on the basis of floristics. A structural analysis of the area yielded communities which did not correlate with environmental parameters. Temporal aerial photographic analysis showed that alien vegetation, recreational, residential and industrial areas have increased since 1936, whereas open sand and natural vegetation have decreased. These data can be used to guide management of the False Bay coast.

Cape fynbos studies

A semi-detailed regional ecological study of the western lowland fynbos. Mr C. Boucher is finalizing the text of the classification and description of the western coastal lowland fynbos for publication. Final editing in respect of, *inter alia*, the nomenclature of plant species is being attended to. All the maps have been completed and tables and photographs require finalizing for publication quality.

The vegetation of the Cedarberg. Detailed facet proposals for the ecological studies of the mountain fynbos and other vegetation on the Cedarberg have been drawn up and approved. Mr H. C. Taylor has concentrated his fieldwork on the northern Cedarberg where nested quadrats to determine optimum plot size indicate that a quadrat size of 5 m × 10 m, with a surround of 1,5 m to bring the total area to 100 m², is sufficient for most Cedarberg fynbos communities. Stratification of aerial photographs in the northern sector revealed some fourteen landscape units aligned along two distinct gradients, north-south and east-west, suggesting that two transects are needed in this sector.

The vegetation of the Langeberg. Mr D. J. McDonald's detailed facet proposals have been drawn up and approved. Four transects for the sampling of the vegetation of the Langeberg have been selected. Fieldwork has

commenced on the transect through the Boesmansbos Wilderness Area, Grootvadersbosch State Forest. To date, 55 relevés have been sampled in Mountain Fynbos vegetation. A further 80–100 samples are envisaged to complete sampling of this transect, which will include relevés in the remnant Afromontane forest communities.

Grassland studies

Detailed facet proposals have been drawn up for the ecological study of the grassland vegetation of the Amersfoort area of the eastern Transvaal Highveld by Miss B. J. Turner. Field sampling has commenced with the assistance of Mr J. F. van Blerk and Miss K. Longley (Figure 2). An aid to the vegetative identification of grasses in the Amersfoort area has been compiled to assist in the identification of grasses not in flower.



FIGURE 2.—A technician investigating nested quadrats to determine optimal quadrat size for vegetation sampling in the Amersfoort area of the north-eastern Transvaal Highveld.

Ecological bibliography

The 'Ecological bibliography and thesaurus for southern Africa up to 1975' by Miss A. P. Backer, Dr D. J. B. Killick and Dr D. Edwards has now been completed. It will be published in the series *Memoirs of the Botanical Survey of South Africa* No. 52. This memoir aims to fulfil the need for a single publication containing most references of an ecological nature.

Ecological data bank

Steady progress is being made with the accession, storage and processing of vegetational and environmental data for the inventory of vegetational resources. Mrs B. J. Vermeulen is playing a key role. Data are obtained for accession as hard copy in the form of unprocessed field data or in variously processed forms including published or unpublished papers, reports and maps. The PHYTOTAB program package is used for the classification and ordination of data sets.

EXPERIMENTAL ECOLOGY DIVISION

The division, under Dr M. C. Rutherford, has continued to concentrate its research on the disturbance of indigenous fynbos plants through alien plant competition and by substrate disturbance while maintaining active research on the water relations of Karoo plants. The whole division has been centred in Cape Town to promote the effective study of these important aspects of the

Fynbos and Karoo biomes. This also places the division in reasonable reach of examples of all the other biomes of southern Africa determined by the relevant research facet referred to below. Two facets on aquatic plant ecology have been successfully completed and terminated during the year following the appearance of several publications on these by Dr C. F. Musil.

Fynbos germination studies

Dr Musil's results to date indicate that seeds of several fynbos species show maximum germination under low temperatures. This is an important finding in that it suggests that germination is dependent on the cold, wet winter months, irrespective of the season of seed shedding. These and other findings of the germination requirements and reproductive capacities of fynbos plants are being compared with those for invasive alien plant species.

Fynbos competition studies

Miss F. M. Pressinger has determined that the presence of lone *Acacia saligna* seedlings had no significant effect on *Protea repens* seedlings when grown at close proximity at densities up to 2 346 plants m⁻² at this early stage of development. This suggests that *Acacia saligna* may affect *Protea repens* at more advanced stages of development. The officer has also been able to predict the pattern of seed dispersal of *Acacia saligna* in the field and therefore the direction of spread of thickets of this species.

Dr Rutherford has found that the main effect of heavy infestations of alien plant species on the indigenous vegetation of the western Cape lowlands is a function of, at least, soil type, soil moisture, proximity to human settlements, and an interaction between mean annual rainfall and stock browsing pressure. *Rhus laevigata* appears to tolerate the environment created by dense *Acacia saligna* populations more effectively than many other indigenous species and this and other related phenomena are being further researched.

Fynbos transformation studies

Mr G. W. Davis's work has shown that during the summer following rotivation of burned mountain fynbos land, reflectivity of the soil surface was increased and higher soil moisture levels were maintained with lowering of soil temperature. The treatment had no effect on the shoot extension of introduced *Protea cynaroides* and *P. repens* for this period but summer transpiration of *P. cynaroides* was greater on the disturbed sites.

Simulation studies in fynbos

Preliminary simulation to predict pressures on natural populations of fynbos ornamental plants by the wild flower picking industry, has highlighted the problem of peak flowering demand and peak supply being often out of phase. A suitable model structure is currently being developed to make predictions as realistic as possible.

Karoo research

Field research results obtained for Karoo plants by Mr G. F. Midgley have raised important hypotheses that relate reduction in leaf surface area, stomatal resistance and transpiration rates, xylem pressure potentials and root system morphologies to succulent and non-suc-

culent plant forms. These hypotheses are to be expanded and tested in the next phase of the research.

Biome studies

The work on determination of biomes of southern Africa by Dr Rutherford and Mr R. H. Westfall has been concluded and is in press in the *Memoirs of the Botanical Survey of South Africa* series.

PLANT EXPLORATION DIVISION

The division, under Mr M. J. Wells, concentrated its attention on weeds and food plant research. Mr T. H. Arnold has continued to lead the food plant research team from his position as head of the Herbarium Division.

Conservation of germ plasm

The following seed collected by Mr Arnold, was included in the germ plasm bank: 569 collections of *Sorghum bicolor* subsp. *bicolor* and 764 collections of *Pennisetum africanum*. Primitive crop collections being held for potential breeding purposes now total 3 371. Despite the fact that we are splitting and distributing seed collections to various seed banks, we are still concerned about the long-term fate of this germ plasm.

Indigenous food plants

Mr A. A. Balsinhas added a further 80 species to the national food plant data-bank, bringing the total of species included to 1 589. Information was also added to the records of many species already listed. Information gathering by Miss S. E. Chadwick, on 14 priority food plants, mainly members of the Cucurbitaceae continued, with 30 more references being included. Observations on the shelf life of fruits, and on associated fungi and insects were included, as were soil analyses from areas where they were growing. Although not always as tasty as cultivated cucurbits, some of the indigenous species have a longer shelf life, better nutritional characteristics and greater ability to grow in arid, brackish soils.

Primitive crop plants of African origin

Much material of primitive cereal crops grown in the Caprivi and Kavango was collected by Mr Arnold and labelled and catalogued by Miss A. E. Swanepoel. These regions proved to be extremely rich sources of primitive cereal germ plasm. Kavango had a notably high occurrence of Durra sorghums which are Asian in origin and rarely found elsewhere in southern Africa. The characteristics of 524 *Sorghum* collections were analysed in terms of inflorescence morphology, seed colour and tannin content. A survey of crop frequency and preference was also extended to Caprivi and Kavango. All except three of the priority areas for primitive cereal crops in South Africa and South West Africa/Namibia have now been included in the survey and collecting programme.

Miss Swanepoel, who joined our staff in February 1986, took over from Mrs K. J. Musil who resigned in July 1985, and assists Mr Arnold with his food plant research.

Barrier plants

The survey of barrier plants by Miss L. Henderson is complete and is scheduled for publication in 1986/87.

The memoir will present information on 504 species (of which 220 are indigenous and 42 are illustrated) and suggests indigenous barrier plants that can be grown instead of invasive alien ones.

Woody invaders

A popular version of the report on woody plant invaders of the Transvaal with 16 colour illustrations has been prepared for publication by Miss Henderson. It will enable laymen to identify the worst plant invaders, and gives hints on their control. In July 1985 Miss Henderson transferred from our staff to the staff of the Plant Protection Research Institute, with whom we work closely, and will concentrate on surveys of invader plants in future.

National weed list

Preparation for publication of the expanded 'National weed list', now titled 'A catalogue of problem plants in southern Africa' was completed by Mr Wells and his team. It will appear shortly as number 53 in the *Memoirs of the Botanical Survey of South Africa* series. It provides basic information on 1 653 species and includes a list of 711 invasive alien species, and a common name index incorporating more than 8 000 names. Its appearance is expected to stimulate the collection of many more data, which may result in the preparation of an enlarged, second edition in several years' time. Already much additional information has been collected on the alien invader plants on the subcontinent by Mrs Musil, Mr Balsinhas and others. This has been incorporated in a preliminary account of the history of introduction of invasive aliens (in press).

Declared weeds and invader plants

A publication has been prepared by Mrs D. M. C. Fourie and co-workers, to enable members of the public and law enforcement officers to identify the 47 species of declared weeds and 9 species of declared alien invader plants covered by the provision of the 'Conservation of Agricultural Resources Act' of 1983. It is based on an earlier publication 'Common weeds in South Africa' by Henderson & Anderson (1966) and includes black and white illustrations, descriptions, a copy of the relevant legislation and advice on control.

Water conservation gardening

The drought has maintained public interest in water conservation gardening, resulting in continued demand for the publication by Mrs D. M. C. Fourie (Department of Agriculture and Water Supply, Bulletin 402), and for lectures on the subject.

Garden utilization

Mrs H. Joffe of the Plant Protection Research Institute, who had been assisting with the preparation of the catalogue of problem plants, transferred to our staff in June 1985. Her new task is to improve scientific utilization of the botanical garden in various ways including taking specimens and photographs.

Scientific information service

Mrs Fourie handled 255 written and 259 telephonic requests for information, often involving the identification of exotic plants. She also dealt with 39 visiting researchers and two groups.

Liaison service

Mrs S. D. Hewitt dealt with 1 172 non-scientific visitors including 28 groups (mainly of school children). The flow of visitors requiring educational services has fallen off markedly as a result of the economic situation.

Pretoria National Botanical Garden

Despite the drought and many staff changes, the garden under Mr D. H. Dry continued to prosper. Staff changes included the resignations of: Mr K. D. Panagos (July 1985), Miss S. C. Kruger (November 1985) and Mr H. J. de Villiers (December 1985); Mr H. J. N. de Beer retired (April 1986). Mrs B. C. de Wet was transferred to Datametrics in January 1986 and Miss J. A. Taussig was transferred to the Herbarium Division in September 1985. On the positive side, Mr N. A. Klapwijk was appointed in January 1985 and other vacant posts have been filled since the report year ended, but for many months the staff position in the garden was critical. We were fortunate that during this testing time our existing boreholes continued to deliver and a new one came into production.

Other new developments included the completion of most of the fencing and paving of the new eastern access road, completion of three paths along the nature trail and the installation of new garden benches (Figure 3). The living plant collection grew by 784 accessions, mostly



FIGURE 3.—One of the new garden benches which have been installed in the garden. Two members of staff, Mrs J. Mogford and Mrs C. du Plessis enjoy the shady spot at lunchtime.



FIGURE 4.—Mr D. S. Hardy admiring an *Erythrina mendesii* in the new Namib shade house at the nursery. The succulent just behind the flowering plant is *Cyphostemma uter* (Exell & Mendonca) Desc.

collected for the Karoo Biome by Miss Kruger, who directed further development of the karoo koppies where 126 shrubs and 3 000 ground cover plants were established. Mr D. S. Hardy was responsible for the re-planting of a large shade house with rare and endangered

species from Namaqualand and the Namib (Figure 4). A large amount of research material, including 317 grasses, was also accessioned. The garden records team, Mrs De Wet and Mrs K. P. Clarke, concentrated on upgrading the labelling of the savanna biome.

BOTANICAL RESEARCH INSTITUTE

Scientific, Technical and Administrative Staff

(31st March 1986)

Director

B. de Winter, M.Sc., D.Sc. (Taxonomy of Poaceae, especially *Eragrostis* and of *Hermannia*; plant geography)

Deputy Director

D. J. B. Killick, M.Sc., Ph.D., F.L.S. (General taxonomy, nomenclature, mountain ecology and editing)

ADMINISTRATION

Provisioning Administration Officer	Mrs D. J. Gerber
State Accountant	Mrs J. Rautenbach
Senior Provisioning Administration Clerks	Miss W. J. Geldenhuys Mrs S. Swanepoel Mrs I. A. Ebersohn Mrs J. van Niekerk, B.A. (Ed.)
Personal Secretary to Director	Mrs M. M. Loots
Senior Registration Clerk	Mrs I. J. Joubert*
Registration Clerk	Mrs C. du Plessis
Accounting Clerk	Miss B. A. Language
Receptionist	Miss L. Lippi
Typists	Mrs S. S. Brink Mrs E. L. Bunton* Mrs S. M. Thiarth* Mrs M. P. M. C. van der Merwe* Mrs J. M. Mulvenna

HERBARIUM DIVISION

Officer-in-Charge

T. H. Arnold, M.Sc.

NATIONAL HERBARIUM, PRETORIA (PRE)

Assistant Director	T. H. Arnold, M.Sc. (Curator)
Provisioning Administration Clerk	Mrs C. J. van Niekerk

Wing A (Pteridophytes–Monocotyledons)

Senior Agricultural Researcher	Miss C. Reid, B.Sc. Hons (Cyperaceae)
Chief Agricultural Research Technician	Mrs L. Fish, B.Sc. (Poaceae)

Herbarium Assistants	Mrs S. Burger Mrs P. W. van der Helde
----------------------------	--

Wing B (Piperaceae–Oxalidaceae)

Senior Agricultural Researcher	G. Germishuizen, M.Sc. (Polygonaceae)
Agricultural Researcher ...	Mrs C. M. van Wyk, M.Sc. (Cape flora & Geraniaceae)
Assistant Agricultural Researcher	A. Nicholas, M.Sc. (General identifications)
Chief Agricultural Research Technician	Mrs B. J. Pienaar, B.Sc. Hons (<i>Vigna</i>)
Administrative Assistant III	C. Letsoalo

Wing C (Linaceae–Asclepiadaceae)

Senior Agricultural Researcher	Miss E. Retief, M.Sc. (Cucurbitaceae, fruit & seed collection)
Agricultural Researcher ...	Miss K. L. Immelman, M.Sc.
Agricultural Research Assistant	A. A. Balsinhas**
Herbarium Assistant	Mrs J. L. M. Grobler*

Wing D (Convolvulaceae–Asteraceae)

Senior Agricultural Researcher	Miss W. G. Welman, M.Sc. (Asteraceae)
Senior Agricultural Research Technician	Mrs M. J. A. W. Crosby*, B.Sc.
Administrative Assistant III	J. Phahla

Cryptogamic Herbarium

Agricultural Researcher ...	F. A. Brusse, M.Sc. (Lichens)
Assistant Agricultural Researcher	J. van Rooy, B.Sc. Hons (Musci)
Chief Agricultural Research Technician	Mrs S. M. Perold*, B.Sc. (SEM technician, Ricciaceae)
Herbarium Assistant	Mrs L. Filter*

Services

Agricultural Researcher ...	Mrs E. van Hoepen, M.Sc. (Controlling officer)
Herbarium Assistants	Mrs M. Dednam* (Identification records) Mrs M. Z. Heymann* (Loans and exchanges)
Typist	Mrs A. M. Verhoef

* Half-day

** Part-time

Administrative Assistant III G. Lephaka (Preparation and packaging)

NATAL HERBARIUM, DURBAN (NH)

Senior Agricultural Research Technician Mrs M. Jordaan, B.Sc. (Curator, Celastraceae, general identifications)

Provisioning Administrative Clerk Mrs H. E. Noble*

Administrative Assistants III C. N. Buthelezi

Administrative Assistants II A. M. Ngwenya

S. H. Nzimande (Messenger)

S. B. Nzimande (Gardener)

ALBANY MUSEUM HERBARIUM, GRAHAMSTOWN (GRA)

Senior Agricultural Researcher Mrs E. Brink, B.Sc. (Curator, general identifications)

Assistant Agricultural Researcher Mrs A. F. M. G. Jacot Guillarmod*, D.Sc.

Herbarium Assistant Mrs M. L. Furlong

Administrative Assistants III A. D. Booie
R. Klaas (Grahamstown Nature Reserve)

Administrative Assistant I J. Zenzile

GOVERNMENT HERBARIUM, STELLENBOSCH (STE)

Senior Agricultural Researcher R. O. Moffett, M.Sc. (Curator, *Rhus* and Asteraceae)

Assistant Agricultural Researcher Miss P. Burger, B.Sc. Agric.

Chief Agricultural Research Technician Mrs A. C. Fellingham, B.Sc. (General identifications)

Herbarium Assistant Miss K. Louw

Administrative Assistants III Mrs J. Leith
Miss E. van Wyk

FLORA RESEARCH DIVISION

Officer-in-Charge G. E. Gibbs Russell, Ph.D., F.L.S.

Assistant Director G. E. Gibbs Russell, Ph.D., F.L.S. (Taxonomy of Poaceae, plant geography, electronic data processing)

Senior Agricultural Researchers E. G. H. Oliver, M.Sc. (Taxonomy of Ericaceae)

J. M. Anderson, M.Sc., Ph.D. (Palaeobotany, plant geography)

Agricultural Researchers Miss K. L. Immelman, M.Sc. (Taxonomy, especially Acanthaceae, Urticaceae)

H. P. Linder, Ph.D. (Taxonomy of Restionaceae, Orchidaceae, Poaceae)

B. D. Schrire, M.Sc. (Taxonomy of Fabaceae, electronic data processing)

Senior Agricultural Research Technician Mrs H. M. Anderson*, M.Sc., Ph.D. (Palaeobotany)

Graphic Artist Miss G. C. Condry, M.A.

Agricultural Research Assistant Mrs W. J. G. Roux* (Plant distributions, specimen administration)

DATA SUBDIVISION

Data Officer..... G. E. Gibbs Russell, Ph.D., F.L.S.

Datametrician..... Mrs B. C. de Wet, B.Sc., B.A., H.D.L.S.*† (Programming for PHYTO-TAB)

Agricultural Research Technician Mrs J. C. Mogford, B.Sc. (Quality control for PRECIS, Database manager since July 1985)

Agricultural Research Assistants Mrs E. B. Evenwel (Quality control for PRECIS)

Mrs H. von Rönge (New specimen encoder for PRECIS)

BIOSYSTEMATICS DIVISION

Officer-in-Charge O. A. Leistner, M.Sc., D.Sc., F.L.S.

Assistant Director O. A. Leistner, M.Sc., D.Sc., F.L.S. (Editing)

Senior Liaison Officer..... Mrs E. P. du Plessis, B.Sc. Hons, S.E.D. (Editing and translating)

Senior Agricultural Research Technician Mrs B. A. Momberg*, B.Sc. (Editing)

PLANT STRUCTURE AND FUNCTION DIVISION

Officer-in-Charge R. P. Ellis, M.Sc., D.Sc.

COMPARATIVE LEAF ANATOMY

Assistant Director..... R. P. Ellis, M.Sc., D.Sc. (Anatomy of grasses)

* Half-day

† Biometry and Datametrics

Senior Agricultural Re- P. P. J. Herman, M.Sc.
searcher (Wood anatomy)
Agricultural Research As- Mrs H. Ebertsohn (Micro-
sistant technique)

CYTOGENETICS

Senior Agricultural Re- J. J. Spies, M.Sc., D.Sc.
searcher (Cytogenetics of gras-
ses)
Agricultural Research- Miss H. du Plessis, B.Sc.
Technicians (Cytogenetics of gras-
ses)
Miss A. Jonker, B.Sc.
(Cytogenetics of gras-
ses)

PHOTOGRAPHIC SERVICES

Photographer Mrs. A. J. Romanowski

MARY GUNN LIBRARY

Senior Librarian Mrs E. Potgieter*, B.Libr.
Library Assistant Mrs B. F. Lategan*†

VEGETATION ECOLOGY DIVISION

Officer-in-Charge J. C. Scheepers, M.Sc.,
D.Sc.

Assistant Director J. C. Scheepers, M.Sc.,
D.Sc. (Vegetation ecol-
ogy, especially of
forest / woodland /
grassland relationships;
conservation and land-
use planning; phytogeo-
graphy)

Senior Agricultural Re- H. C. Taylor, M.Sc.
searchers (Mountain fynbos and
forest ecology; Braun-
Blanquet approach and
techniques; conserva-
tion)

P. J. Weisser, Ph.D. (for-
est ecology; air-photo
interpretation and map-
ping; reedswamp ecol-
ogy; Zululand coast-
dune vegetation; conser-
vation)

R. H. Westfall, M.Sc.
(Ecology and phytoso-
ciology of Transvaal
bushveld; ecological
data and literature stor-
age, retrieval and pro-
cessing; syntaxonomic
nomenclature)

Agricultural Researchers ... D. J. McDonald, M.Sc.
(Mountain fynbos ecol-

ogy and phytosocio-
logy; Braun-Blanquet
approach and techni-
ques)

G. B. Deall, M.Sc. (Vege-
tation ecology of forest/
woodland / grassland in-
terrelationships)

M. G. O'Callaghan, M.Sc.
(Estuarine ecology and
phytosociology)

Assistant Agricultural Re- Miss B. J. Turner, B.Sc.
searchers Hons (Grassland ecol-
ogy; pasture science;
nature conservation)

J. M. van Staden, B.Sc.
Hons (Bushveld ecol-
ogy; pasture science;
nature conservation)

Senior Agricultural Re- Miss A. P. Backer, B.Sc.
search Technicians (Ecological data
processing and presenta-
tion; ecological litera-
ture; nature conserva-
tion; air-photo interpre-
tation and cartography)

M. D. Panagos, N. Dipl.
Agric. (Bot. Res.)
(Computer science; data
processing; sampling
and monitoring vegeta-
tion and environment)

Agricultural Research Miss K. A. Longley,
Technicians B.Sc. (Sampling and
monitoring vegetation
and environment)

Miss M. Morley, B.Sc.
Agric. (Ecological data
processing and presen-
tation; ecological litera-
ture; estuarine and fyn-
bos vegetation; air-
photo interpretation and
cartography)

Mrs J. Schaap, H.P.E.D.
(Draughtsmanship and
cartography; artwork,
layout and design)

Miss A. Stadler, B.Sc.
(Ecological data pro-
cessing and presenta-
tion; ecological litera-
ture; nature conserva-
tion; air-photo interpre-
tation and cartography)

J. F. van Blerk, B.Sc.
(Grassland and karoo
ecology; ecological lit-
erature; pasture science)

Mrs B. J. Vermeulen,
B.Sc. For. (Nat. Cons.)
(Ecological data bank-
ing; information sys-
tems; syntaxonomic
nomenclature)

* Library Services, Department of National Education

† Half-day

EXPERIMENTAL ECOLOGY DIVISION

Officer-in-Charge	M. C. Rutherford, M.Sc., Ph.D., Dipl. Datamet.		(Weeds research, botanical horticulture, fynbos utilization and conservation)
Assistant Director	M. C. Rutherford, M.Sc., Ph.D., Dipl. Datamet. (Primary production ecology of terrestrial ecosystems; experi- mental ecological stu- dies in fynbos and Karoo)	Senior Agricultural Re- searchers	Miss. L. Henderson, B.Sc. Hons (Cover and barrier plants, woody exotic invaders)
Senior Agricultural Re- searcher	C. F. Musil, M. Sc., Ph.D. (Reproductive ecophysiology in fyn- bos)	Assistant Agricultural Re- searcher	Miss S. E. Chadwick, B.Sc. Hons (Indigenous food plants and primi- tive crops)
Agricultural Researcher...	Miss F. M. Pressinger, B.Sc. Hons (Ecophysio- logical studies of com- petitive stress in fynbos ecosystems)	Principal Agricultural Re- search Technician	Mrs D. M. C. Fourie*, B.Sc. (Scientific infor- mation service)
Assistant Agricultural Re- searchers	G. W. Davis, M.Sc. (Transformations of fynbos ecosystems by the wild flower picking industry) G. F. Midgley, B.Sc. Hons (Plant water rela- tions in Karoo eco- systems)	Agricultural Research Technicians	A. A. Balsinhas** (Indi- genous food plant data bank) Mrs H. Joffe*, B.Sc. (Garden utilization) Miss A. E. Swanepoel, B.Sc. (Crop plants of African origin)
		Liaison Officer	Mrs S. D. Hewitt, B.A. (Public relations)
Agricultural Research Technicians	A. P. Flynn, B.Sc. (Fyn- bos ecology; plant com- munity development) J. de W. Bösenberg, B.Sc. Hons (Karoo and fynbos ecology; monitoring effects of alien plants on fynbos)		
Agricultural Research Assistant	D. M. de Witt (Labora- tory, field and curatorial assistance)		

PLANT EXPLORATION DIVISION

Officer-in-Charge	M. J. Wells, M.Sc.
Assistant Director	M. J. Wells, M.Sc.

* Half-day

** Part time

PRETORIA NATIONAL BOTANICAL GARDEN

Chief Agricultural Re- search Technician (Curator)	D. H. Dry, NTC (Hort.) Dipl.
Senior Agricultural Re- search Technician	D. S. Hardy (Nursery supervision, succulents and orchids)
Pupil Agricultural Re- search Technician	N. A. Klapwijk
Agricultural Research Assistants	Mrs K. P. Clarke (Garden records) Miss J. A. Taussig, Nat. Dipl. (Hort.)
Farm Foremen	H. N. J. de Beer L. C. Steenkamp

PUBLICATIONS BY THE STAFF
(1985.04.01-1986.03.31)

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- section *Pilifer*: *R. duthieae* and *R. alatospora*. *Bothalia* 15: 531-539.
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Book Reviews

GRASSES OF SOUTH WEST AFRICA/NAMIBIA by M. A. N. MÜLLER. *Directorate of Agriculture and Forestry, Department of Agriculture and Nature Conservation, South West Africa/Namibia*. 1984. Pp. 287, numerous black-and-white photographs and 116 line drawings. Price R9,90 excl. GST.

The book is a field guide to the agriculturally important grasses of South West Africa/Namibia. It is divided into two parts. Part 1 is concerned with the vegetation types of South West Africa/Namibia, based on Giess's preliminary vegetation map published in *Dinteria* 4 of 1971. A clear, coloured map shows the distribution of 14 of these vegetation types, but the 15th vegetation type, Riverine Woodland, is not mapped. The vegetation types are illustrated by black-and-white photographs and are briefly described with some of the common plant species listed.

Part 2 deals with the grasses. Introductory information consists of a line drawing showing the structure of a grass plant, followed by a brief glossary of botanical terms. Unfortunately, the glossary is incomplete since terms such as keeled, tripartite, pedicel and peduncle are used in the text but are not defined in the glossary and could confuse the layman or amateur botanist. Another term used is 'omiramba', an Ovambo word apparently referring to a dry river bed. This term is not widely known outside the territory and should therefore be defined in the book.

Grass inflorescences are classified into five basic types, and simple and advanced keys to the grass genera are given. The simple key uses macroscopic floristic and vegetative characters whereas the advanced key uses floristic characters requiring 10× magnification.

The bulk of Part 2 consists of descriptions of 115 grass species, arranged alphabetically by genus and species. Lastly, there are four indices; an index to botanical names and indices to common names in English, Afrikaans and German.

In the species treatments the following information is given: origin of the scientific name; common names in English, Afrikaans and German; inflorescence type; a description in terms of habit and vegetative and floristic characters; distribution; and general information including seral status, habitat, soils, palatability, and in some cases, economic value. Accompanying the written text are clear line drawings illustrating the habit, inflorescence, spikelet and the ligule; a distribution map; and for some species, a black-and-white photograph showing the habit.

The simple key to the genera will help considerably in identifying the grasses to genus level, and the detailed line drawings and the descriptions will permit the identification of species. In view of the absence of keys to the species, it is a pity that distinguishing characters are not given for each species, as is done in Chippindall and Crook's *240 grasses of southern Africa* (1976). Furthermore, the floristic data for each species are not very detailed. Data given include: inflorescence shape, size and branching; spikelet length, colour and sometimes shape; and presence of pedicels, hairs and awns. Mention is only rarely made of the number of flowers in a spikelet and the sexuality of the florets.

This book will succeed in assisting the farmer and the layman in identifying and getting to know grasses. The inclusion of common names will help the person who is only familiar with these names to find a species in the book. The inclusion of general information about each species imparts useful knowledge on the value and the ecology of the plant.

As a general field guide this book will be of value to the botanist. Its major shortcoming is the absence of a key to the species. It would help if greater floristic detail had been included to ensure a more reliable identification than would be obtained by matching a plant to the drawings and descriptions given. The inclusion of the key to the four

subspecies of *Aristida stipitata* is most useful, as are the occasional notes describing the differences between similar species.

As is the case with most publications aimed at assisting in grass identification, insufficient attention is given to the vegetative characters of each species. This book does describe a range of vegetative characters, but easily determined characters such as ligule length and shape, leaf shape and nature (eg. serrated), etc. are not given consistent attention. Vegetative characters can be diagnostic and so assist in identification. The heavy reliance on floristic characters for grass identification limits the usefulness of such a book to the period when the plants are in flower. A more complete and systematic description of the vegetative characters of a species would be very useful, particularly for the person who is required to identify grass species at all times of the year.

A more serious defect in the book is that the title may lead the reader to suppose that all grasses in South West Africa/Namibia are covered. However, the 115 species represented are only about a third of the 350 grass species recorded for the territory. Only in one sentence in the Introduction is it stated that the 115 species were selected for agricultural importance, but even then the total size of the known grass flora, and therefore the coverage of the work, is not made clear. This omission renders an absolute disservice to our knowledge of the plants of the area in two ways: first, a casual user may experience great difficulty in attempting to identify one of the 235 grasses from South West Africa/Namibia that do not appear in the book; second, and more seriously, a false impression is given about the size and complexity of an extremely important component of the flora. This false impression in a book destined for a wide spectrum of users can have an adverse effect on planning for agricultural extension and nature conservation if systems are depicted as being less complex than they really are.

BEVERLEY TURNER

FLORA OF AUSTRALIA (Vol. 46). Iridaceae to Dioscoreaceae, edited by ALEXANDER S. GEORGE. *Australian Government Publishing Service, Canberra*. 1986. Pp 247, line drawings and 16 colour photographs; 248 maps. Price \$A 26.00 (soft cover edn), \$A 30.00 (casebound edn).

Volume 46 is the seventh to be published and covers the families Iridaceae, Aloeaceae, Agavaceae, Xanthorrhoeaceae, Hanguanaceae, Taccaceae, Stemonaceae, Smilacaceae, and Dioscoreaceae, arranged according to Cronquist, *An integrated system of classification of flowering plants* (1981). There are 14 contributors.

Volume 22 was reviewed by Oliver in *Bothalia* 15: 778 (1985), and much of the discussion and criticism contained therein applies also to the present volume. One worthwhile change noted is that all the distribution maps are grouped together at the end of the book, rather than in pages of 15 maps at a time scattered throughout.

As usual the frontispiece and dustjacket bear an attractive colour painting of an included species, in this case *Patersonia australis* R. Br. The colour photographs are of doubtful taxonomic value but do add interest to the volume.

It is interesting to note that roughly three-quarters of the Iridaceae flora is introduced, much of it from Cape Province, South Africa, and that a number of these introductions are becoming serious weeds. In many cases they are becoming extinct in their native habitat. Unfortunately in Aloeaceae, the South African introduction *Aloe maculata* All. is listed as its synonym, *A. saponaria* (Ait.) Haw. Nomenclature of this species was discussed by Dandy in *Taxon* 19: 617 (1970). (The southern African species are currently under revision by H.F. Glen and D.S. Hardy for the *Flora of southern Africa*.)

The stated editorial policy for *Flora of Australia*, of using simple descriptive terms makes this a very easy-to-use Flora. Its conciseness is maintained by placing descriptions of new taxa, new combinations and lectotypifications in the appendix, which also contains a very useful supplementary glossary plus a list of contractions and abbreviations.

C. REID

Guide for authors to Bothalia

This guide is updated when necessary. The latest version should therefore be consulted.

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the Botanical Research Institute is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

EDITORIAL POLICY

Bothalia welcomes original papers dealing with flora and vegetation of southern Africa and related subjects. Full-length papers and short notes, as well as book reviews, are accepted. Manuscripts may be written in either English or Afrikaans.

Articles are assessed by referees at the discretion of the editor. Authors are welcome to suggest possible referees to judge their work. Authors are responsible for the factual correctness of their contributions. *Bothalia* maintains an editorial board (see title page) to ensure that international standards are upheld.

PRESENTATION OF MANUSCRIPT

Manuscripts should be typewritten on one side of good quality A4-size paper, double-spaced throughout (including abstract, tables, captions to figures, literature references etc.) and have a margin of at least 30 mm all round. The original and three photocopies (preferably photocopied on both sides of the paper to reduce weight for postage) of all items, including text, illustrations, tables and lists should be submitted, and the author should retain a complete set of copies. Papers should conform to the general style and layout of recent issues of *Bothalia* (from Volume 14 onwards). Material should be presented in the following sequence: Title page with title, name(s) of author(s), keywords, abstracts (in English and Afrikaans) and information that should be placed in a footnote on the title page, such as address(es) of author(s) and mention of granting agencies. The sequence continues with Introduction and Aims, Material and Methods, Result, Interpretation (Discussion), Acknowledgements, Specimens examined (in revisions and monographs), References, Index of Names (recommended for revisions dealing with more than about 15 species), Tables, Captions for figures and figures. In the case of short notes and book reviews, keywords and abstract are superfluous. All pages must be numbered consecutively beginning with the title page to those with references, tables and captions to figures.

AUTHOR(S)

When there are several authors the covering letter should indicate clearly which of them is responsible for correspondence and, if possible, telephonically available while the article is being processed. The contact address and telephone number should be mentioned if they differ from those given on the letterhead.

TITLE

The title should be as concise and as informative as possible. In articles dealing with taxonomy or closely

related subjects the family of the taxon under discussion (see also *Names of taxa* under General below) should be mentioned in brackets but author citations should be omitted from plant names.

KEYWORDS

Up to 10 keywords (or index terms) should be provided in English in alphabetical sequence. The following points should be borne in mind when selecting keywords:

- 1, Keywords should be unambiguous, internationally acceptable words and not recently-coined little-known words; 2, they should be in a noun form and verbs should be avoided; 3, they should not consist of an adjective alone; adjectives should be combined with nouns; 4, they should not contain prepositions; 5, the singular form should be used for processes and properties, e.g. evaporation; 6, the plural form should be used for physical objects, e.g. augers; 7, location (province and/or country); taxa (species, genus, family) and vegetation type (community, veld type, biome) should be used as keywords; 8, keywords should be selected hierarchically where possible, e.g. both family and species should be included; 9, they should include terms used in the title; 10, they should answer the following questions: 10.1, what is the *active concept* in the document (activity, operation or process); 10.2, what is the *passive concept* or object of the active process (item on which the activity, operation or process takes place); 10.3, what is the means of accomplishment or how is the active concept achieved (technique, method, apparatus, operation or process); 10.4, what is the environment in which the active concept takes place (medium, location) and 10.5, what are the independent (controlled) and dependent variables? 11, questions 10.1 to 10.3 should preferably also be answered in the title.

ABSTRACT

Abstracts of no more than 200 words should be provided in English and Afrikaans. Abstracts are of great importance and should convey the essence of the article. They should refer to the geographical area concerned and, in taxonomic articles, mention the number of taxa treated. They should not contain information not appearing in the article. In articles dealing with taxonomy or closely related subjects all taxa from the rank of genus downwards should be accompanied by their author citations. Names of new taxa and new combinations should not be underlined. If the article deals with too many taxa only the important ones should be mentioned.

TABLE OF CONTENTS

A table of contents should be given for all articles longer than about six typed pages, unless they follow the strict format of a taxonomic revision.

ACKNOWLEDGEMENTS

Acknowledgements should be kept to the minimum compatible with the requirements of courtesy. Please give all the initials of the person(s) you are thanking.

LITERATURE REFERENCES

In text

Literature references in the text should be cited as follows: 'Jones & Smith (1986) stated . . .' or '. . .

(Jones & Smith 1986)' when giving a reference simply as authority for a statement. When more than two authors are involved use the name of the first author followed by *et al.* When referring to more than one literature reference, they should be arranged alphabetically according to author and separated by a semicolon, e.g. (Anon. 1981, 1984; Davis 1976; Nixon 1940). Titles of books and names of journals should preferably not be mentioned in the text. If there is good reason for doing so, they should be treated as described in the paragraph *In reference list* below. Personal communications are given only in the text, not in the list of references. Please add the person's full initials to identify the person more positively.

In taxonomic articles

The correct name (not underlined) is to be followed by its author citation (underlined) and the full literature reference, with the name of the publication written out in full. Thereafter all literature references, including those of the synonyms, should only reflect author, page and year of publication, e.g. C. E. Hubb. in Kew Bulletin 15: 307 (1960); Boris *et al.*: 14 (1966); Boris: 89 (1967); Sims: t. 38 (1977). Note that (1) references are arranged in chronological sequence; (2) where two or more references by the same author are listed in succession, the author's name is repeated with every reference; (3) names of authors are written in the same way (see *Names of authors of plant names* under General), irrespective of whether the person in question is cited as the author of a plant name or of a publication; (4) the word 'figure' is written as 'fig.', and 't.' is used for both 'plate' and 'tablet'.

Literature references providing good illustrations of the species in question may be cited in a paragraph commencing with the word *Icones* followed by a colon. This paragraph is given after the last paragraph of the synonymy.

In reference list

All publications referred to in the text, including those mentioned in full in the treatment of correct names in taxonomic papers, but no others, and no personal communications, are listed at the end of the manuscript under the heading References. The references are arranged alphabetically according to authors and chronologically under each author, with a, b, c, etc. added to the year if the author has published more than one work in a year. If an author has published both on his own and as a senior author with others, the solo publications are listed first and after that, in strict alphabetical sequence, those published with one or more other authors. Author names are typed in capitals. Titles of journals and of books are written out in full and are underlined as follows: *Transactions of the Linnean Society of London* 5: 171–217, or *Biology and ecology of weeds*: 24. Titles of books should be given as in *Taxonomic literature*, edn 2 by Stafleu & Cowan and names of journals as in *World list of scientific periodicals*, edn 4. If the same author is mentioned more than once the name is written out in full and not replaced by a line.

Examples of references:

Collective book or Flora

BROWN, N. E. 1909. Asclepiadaceae. In W. T. Thiselton-Dyer, *Flora capensis* 6,2: 518–1036. Reeve, London.

BROWN, N. E. 1915. Asclepiadaceae. In W. T. Thiselton-Dyer, *Flora of tropical Africa* 5,2: 500–600. Reeve, London.

Book

DU TOIT, A. L. 1966. *Geology of South Africa*, 3rd edn, S. M. Haughton (ed.). Oliver & Boyd, London.

HUTCHINSON, J. 1946. *A botanist in southern Africa*. Gawthorn, London.

Journal

MORRIS, J. W. 1969. An ordination of the vegetation of Ntshongweni, Natal. *Bothalia* 10: 89–120.

STEBBINS, G. L. Jr 1952. Aridity as a stimulus to plant evolution. *American Naturalist* 86: 35–44.

SMOOK, L. & GIBBS RUSSELL, G. E. 1985. Poaceae. *Memoirs of the Botanical Survey of South Africa* No. 51: 45–70.

In press, in preparation

TAYLOR, H. C. in press. *A reconnaissance of the vegetation of Rooiberg State Forest*. Department of Forestry, Technical Bulletin.

VOGEL, J. C. 1982. The age of the Kuiseb River silt terrace at Homeb. *Palaeoecology of Africa* 15. In press.

WEISSER, P. J., GARLAND, J. F. & DREWS, B. K. in prep. Dune advancement 1937–1977 and preliminary vegetation succession chronology at Mlalazi Nature Reserve, Natal, South Africa. *Bothalia*.

Thesis

KRUGER, F. J. 1974. *The physiography and plant communities of the Jakkalsrivier Catchment*. M. Sc. (Forestry) thesis, University of Stellenbosch.

Miscellaneous paper, report, unpublished article, technical note, congress proceedings

ANON. no date. *Eetbare plante van die Wolkberg*. Botanical Research Unit, Grahamstown. Unpublished.

BAWDEN, M. G. & CARROL, D. M. 1968. *The land resources of Lesotho*. Land Resources Study No. 3, Land Resources Division, Directorate of Overseas Surveys, Tolworth.

BOUCHER, C. 1981. Contributions of the Botanical Research Institute. In A. E. F. Heydon, *Proceedings of workshop research in Cape estuaries*: 105–107. National Research Institute for Oceanology, CSIR, Stellenbosch.

NATIONAL BUILDING RESEARCH INSTITUTE 1959. *Report of the committee on the protection of building timbers in South Africa against termites, woodboring beetles and fungi*, 2nd edn, CSIR Research Report No. 169.

TABLES

Each table should be presented on a separate sheet and be assigned an Arabic numeral, i.e. the first table mentioned in the text is marked 'Table 1'. In the captions of tables the word 'table' is written in capital letters. See recent numbers of *Bothalia* for the format required. Avoid vertical lines, if at all possible. Tables can often be reduced in width by interchanging primary horizontal and vertical heads.

FIGURES

General

Figures should be planned to fit, after reduction, into a width of either 80, 118 or 165 mm, with a maximum vertical length of 240 mm. Allow space for the caption in the case of figures that will occupy a whole page. It is recommended that drawings should be twice the size of the final reproduction. Lettering and numbering on all figures should be done in lettraset, stencilling or a comparable method. If symbols are to be placed on a dark background it is recommended that black symbols are used on a small white disk or square. If the lettering or wording on a figure is to be done by the printer this

information must be typed or neatly printed on a photocopy of the figure or on an overlay attached to the original. If several illustrations are treated as components of a single composite figure they should be designated by capital letters. Note that the word 'figure' should be written out in full, both in the text and the captions. In the text the figure reference is then written as in the following example: 'The stamens (Figure 4A, B, C) are . . .' In captions, 'figure' is written in capital letters. Magnification of figures should be given for the size as submitted. It is recommended, however, that scale bars or lines be used on figures. In figures accompanying taxonomic papers, voucher specimens should be given in the relevant caption. Figures are numbered consecutively with Arabic numerals in the order they are referred to in the text. These numbers, as well as the author's name and an indication of the top of the figure, must be written in soft pencil on the back of all figures. Authors should indicate in pencil in the text where they would like the figures to appear. Authors wishing to have the originals of figures returned must inform the editor in the original covering letter and must mark each original 'To be returned to author'. Authors wishing to use illustrations already published must obtain written permission before submitting the manuscript and inform the editor of this fact. Captions for figures should be collected together and typed on a separate sheet headed *Captions for figures*.

Black and white drawings

Line drawings, including graphs and diagrams, should be in jet-black Indian ink, preferably on bristol board or tracing film. Lines should be bold enough to stand reduction.

Photographs

Photographs should be of excellent quality on glossy paper with clear detail and moderate contrast. Photograph mosaics should be submitted complete, the component photographs mounted neatly on a white card base leaving a narrow gap of uniform width between each print. Note that grouping photographs of markedly divergent contrast results in poor reproductions.

Dot maps

It is strongly recommended that taxonomic articles include dot maps as figures to show the distribution of taxa. Blank maps are available from the editor.

GENERAL

Names of taxa

As a rule authors should use the names as listed by Gibbs Russell *et al.* in *Memoirs of the Botanical Survey of South Africa* Nos 48 and 51. Names of genera and infrageneric taxa are usually underlined with the author citation (where relevant) not underlined. Exceptions include names of new taxa in the abstracts, correct names given in the synopsis or in paragraphs on species excluded from a given supraspecific group in taxonomic articles, in checklists and in indices, where the position

is reversed, correct names being not underlined and synonyms underlined. Names above generic level are not underlined. In articles dealing with taxonomy and closely related subjects the complete scientific name of a plant (with author citation) should be given at the first mention in the text. The generic name should be abbreviated to the initial thereafter, except where intervening references to other genera with the same initial could cause confusion.

Names of authors of plant names

These should agree with the list compiled by the BRI (TN TAX 2/1) which has also been implemented by Gibbs Russell *et al.* in *Memoirs of the Botanical Survey of South Africa* Nos 48 and 51. Modern authors not included in the list should use their full name and initials when publishing new plant names. Other author names not in the list should be in agreement with the recommendations of the Code.

Names of authors of publications

These are written out in full except in the synonymy in taxonomic articles where they are treated like names of authors of plant names.

Names of plant collectors

These are underlined whenever they are linked to the number of a specimen. The collection number is also underlined, e.g. *Acocks 14407*. Surnames beginning with 'De', 'Du' or 'Van' begin with a capital letter unless preceded by an initial.

Measurements

Use only units of the International System of Units (SI). Cm should not be used, only mm and/or m. The use of '±' is recommended.

Numerals

Numbers 'one' to 'nine' are spelled out in normal text and from 10 onwards they are written in Arabic numerals. In descriptions of plants, numerals are used throughout. Write 2,0-4,5 (not 2-4,5). When counting members write 2 or 3 (not 2-3).

Abbreviations

Abbreviations should be used sparingly but consistently. No full stops are placed after abbreviations ending with the last letter of the full word (e.g. edition = edn; editor = ed.), after units of measure, after compass directions and after herbarium designations.

Herbarium voucher specimens

Wherever possible authors should refer to one or more voucher specimen(s) in a registered herbarium.

KEYS TO TAXA

It is recommended that (apart from multi-access keys) indented keys be used with couplets numbered 1a-1b, 2a-2b, etc. (without full stops thereafter). Keys consisting of a single couplet have no numbering. Manuscripts of keys should be presented as in the following example:

- 1a Leaves closely arranged on an elongated stem; a submerged aquatic with only the capitula exserted. 1b. *E. setaceum* var. *pumilum*
1b Leaves in basal rosettes; stems suppressed; small marsh plants, ruderals or rarely aquatics:

- 2a Annuals, small, fast growing pioneers, dying when the habitat dries up; capitula without coarse white setae; receptacles cylindrical:
- 3a Anthers white 2. *E. cinereum*
- 3b Anthers black 3. *E. nigrum*
- 2b Perennials, more robust plants; capitula sparsely to densely covered with short setae:

SPECIES TREATMENT IN TAXONOMIC PAPERS

General presentation

The procedure to be followed is illustrated in the example (under Description and example of species treatment, below), which should be referred to, because not all steps are described in full detail. The correct name (see also *Names of taxa*, under General), with its literature citations is followed by the synonymy (if any), the description and the discussion, which should consist of paragraphs commencing, where possible, with italicised leader words such as *flowering time*, *diagnostic characters*, *distribution* and *habitat*.

Numbering

When more than one species of a given genus is dealt with in a paper, the correct name of each species should be prefixed by a sequential number followed by a full stop, the first line of the paragraph to be indented. Intraspecific taxa are marked with small letters, e.g. 1b., 12c., etc.

Literature references within synonymy

(See above under *Literature references*, paragraph 2.)

Citation of specimens

Type specimen in synopsis

The following should be given (if available): country (if not in RSA), province, locality as given by original collector, modern equivalent of collecting locality in square brackets (if relevant), date of collection (optional), collector's name and collecting number (both underlined). The abbreviation *s.n.* (*sine numero*) is given after the name of a collector who usually assigned numbers to his collections but did not do so in the specimen in question. The herbaria in which the relevant type(s) are housed are indicated by means of the abbreviations given in the latest edition of *Index Herbariorum*. The holotype (holo.) and its location are mentioned first, followed by a semicolon, the other herbaria are arranged alphabetically, separated by commas. Authors should indicate by means of an exclamation mark (!) which of the types have been personally examined. If only a photograph or microfiche was seen, write as follows: *Anon. 422 (Z, holo.-BOL, photo.!).* Lectotypes or neotypes should be chosen for correct names without a holotype. It is not necessary to lectotypify synonyms. When a lecto- or a neotype are newly chosen this should be indicated by using the phrase 'here designated'. If reference is made to a previously selected lectotype or neotype, the name of the designating author and the literature reference should be given. In cases where no type was cited, and none has subsequently been nominated, this may be stated as 'not designated'.

In notes and brief taxonomic articles

In brief papers mentioning only a few species and a few cited specimens, the specimens should be arranged according to the grid reference system:

Provinces/countries (typed in capitals) should be cited in the following order: SWA/Namibia, Botswana, Trans-

vaal, Orange Free State, Swaziland, Natal, Lesotho, Transkei and Cape. Grid references should be cited in numerical sequence. Locality records for specimens should preferably be given to within a quarter-degree square. Records from the same one-degree square are given in alphabetical order, i.e. (-AC) precedes (-AD), etc. Records from the same quarter-degree square are arranged alphabetically according to the collectors' names; the quarter degree references must be repeated for each specimen cited. The relevant international code of the herbaria in which a collection was seen should be given in brackets after the collection number; the codes are separated by commas. The following example will explain the procedure:

NATAL.—2731 (Louwsburg): 16 km E of Nongoma (-DD), *Pelser 354* (BM, K, PRE); near Dwaarsrand, *Van der Merwe 4789* (BOL, M). 2829 (Harrismith): near Groothoek (-AB), *Smith 234*; Koffiefontein (-AB), *Taylor 720* (PRE); Cathedral Peak Forest Station (-CC), *Marrion 74* (KMG); Wilgerfontein, *Roux 426*. Grid ref. unknown: Sterkstroom, *Strydom 12* (NBG).

For records from outside southern Africa authors should use degree squares without names, e.g.:

KENYA.—0136: Nairobi plains beyond race course, *Napier 485*.

If long lists of specimens are given, they should be dealt with as below.

In monographs and revisions

In the case of all major works of this nature it is assumed that the author has investigated the relevant material in all major herbaria and that he has provided the specimens seen with determinavit labels. It is assumed further that the author has submitted distribution maps for all relevant taxa and that the distribution has been described briefly in words in the text. Under the heading 'Vouchers' no more than 5 specimens should be cited, indicating merely the collector and the collector's number (both underlined). Specimens are alphabetically arranged according to collector's name. If more than one specimen by the same collector is cited, they are arranged numerically and separated by a semicolon. The purpose of the cited specimens is not to indicate distribution but to convey the author's concept of the taxon in question.

The herbaria in which the specimens are housed are indicated by means of the abbreviation given in the latest edition of *Index Herbariorum*. They are given between brackets, arranged alphabetically and separated by commas behind every specimen as in the following example:

Vouchers: *Fischer 840* (NH, NU, PRE); *Flanagan 831* (GRA, PRE); *Marloth 4926* (PRE, STE); *Schelte 6161* (BOL); *Schlechter 4451* (BM, BOL, GRA, K, PRE).

All specimens studied by the author should be listed together at the end of the article under the heading *Specimens examined*. They are arranged alphabetically by the collector's name and then numerically for each collector. The species is indicated in brackets by the number that was assigned to it in the text and any infraspecific taxa by a small letter. If more than one genus is dealt with in a

given article, the first species of the first genus mentioned is indicated as 1.1. This is followed by the international herbarium designation. Note that the name of the collector and the collection number are underlined:

Acocks 12497 (21b) BM, K, PRE; *14724* (1.13a) BOL, K, P. *Archer 1507* (4) BM, G.

Burchell 2847 (8c) BM, K. *Burman 2401* (3) MO, S. *Burt 789* (2.6) B, KMG, STE.

Synonyms

In a monograph or a revision covering all of southern Africa, all synonyms based on types of southern African origin, or used in southern African literature, should be included. Illegitimate names are designated by *nom. illeg.* after the reference, followed by *non* with the author and date, if there is an earlier homonym. *Nomina nuda* (*nom. nud.*) and invalid names are excluded unless there is a special reason to cite them, for example if they have been used in prominent publications. Note that in normal text Latin words are italicized, but in the synopsis of a species Latin words such as *nom. nud.* are not italicized.

Synonyms should be arranged chronologically into groups of nomenclatural synonyms, i.e. synonyms based on the same type, and the groups should be arranged chronologically by basionyms, except for the basionym of the correct name which is dealt with in the paragraph directly after that of the correct name. When a generic name is repeated in a given synonymy it should be abbreviated to the initial except where intervening references to other genera with the same initial could cause confusion.

Description and example of species treatment

Descriptions of all taxa of higher plants should, where possible, follow the sequence: Habit; sexuality; underground parts (if relevant). *Indumentum* (if it can be easily described for the whole plant). *Stems/branches*. *Bark*. *Leaves*: arrangement, petiole absent/present, pubescence; blade: shape, size, apex, base, margin; midrib: above/below, texture, colour; petiole; stipules. *Inflorescence*: type, shape, position; bracts/bracteoles. *Flowers*: shape, sex. *Receptacle*. *Calyx*. *Corolla*. *Disc*. *Androecium*. *Gynoecium*. *Fruit*. *Seeds*. *Chromosome number*. Figure (word written out in full) number. As a rule shape should be given before measurements. In general, if an organ has more than one of the parts being described, use the plural, otherwise use the singular, for example, petals of a flower but blade of a leaf. Language must be as concise as possible, using participles instead of verbs. Dimension ranges should be cited as in the example below. Care must be exercised in the use of dashes and hyphens: a *hyphen* is a short stroke joining two syllables of a word, e.g. ovate-lanceolate or sea-green; an *N-dash* (*en*) is a longer stroke commonly used instead of the word 'to' between numerals, '2–5 mm long' (do not use it between words but rather use the word 'to', e.g. 'ovate to lanceolate'), it is produced on a typewriter by typing 2 hyphens next to each other; and an *M-dash* (*em*) is a stroke longer than an N-dash and is used variously, e.g. in front of a subspecific epithet instead of the full species name, it is produced on a typewriter by typing 3 hyphens next to one another. The use of '±' is recommended when describing shape, measurements, dimensions etc.

Example:

1. *Bequaertiodendron magalismontanum* (Sond.) Heine & Hemsl. in Kew Bulletin: 307 (1960); Codd: 72 (1964); Elsdon: 75

(1980). Type: Transvaal, Magaliesberg, *Zeyher 1849* (S, holo. –BOL, photo.)

Chrysophyllum magalismontanum Sond.: 721 (1850); Harv.: 812 (1867); Engl.: 434 (1904); Bottmar: 34 (1919). *Zeyherella magalismontanum* (Sond.) Aubrév. & Pellegr.: 105 (1958); Justin: (1973).

Chrysophyllum argyrophyllum Hiern: 721 (1850); Engl.: 43 (1904). *Boivinella argyrophylla* (Hiern) Aubrév. & Pellegr.: 37 (1958); Justin: 98 (1973). Types: Angola, *Welwitsch 4828* (BM!), lecto., here designated; PRE!; Angola, *Welwitsch 4872* (BM!).

Chrysophyllum wilmsii Engl.: 4, t. 16 (1904); Masonet: 77 (1923); Woodson: 244 (1937). *Boivinella wilmsii* (Engl.) Aubrév. & Pellegr.: 39 (1958); Justin: 99 (1973). Type: Transvaal, Magoebaskloof, *Wilms 1812* (B, holo.; K!, P!, lecto, designated by Aubrév. & Pellegr.: 38 (1958), PRE!, S! W!, Z!).

Bequaertiodendron fruticosum De Wild.: 37 (1923), non Bonpland: 590 (1823); Bakker: 167 (1929); Fries: 302 (1938); Davy: 640 (1954); Breytenbach: 117 (1959); Clausen: 720 (1968); Palmer: 34 (1969). Type: Transvaal, Tzaneen Distr., *Granville 3665* (K, holo.; G!, P!, PRE!, S!).

Bequaertiodendron fragrans auct. non Oldemann: Glover: 149, t. 19 (1915); Henkel: 226 (1934); Stapelton: 6 (1954).

Icones: Harv.: 812 (1867); Henkel: t. 84 (1934); Codd: 73 (1964); Palmer: 35 (1969).

Woody perennial; main branches up to 0,4 m long, erect or decumbent, grey woolly-felted, leafy. *Leaves* 3–10 (–23) × 1,0–1,5 (–4,0) mm, linear to oblanceolate, obtuse, base broad, half-clasping. *Heads* heterogamous, campanulate, 7–8 × 5 mm, solitary, sessile at tip of axillary shoots; involucre bracts in 5 or 6 series, inner exceeding flowers, tips subopaque, white, very acute. *Receptacle* nearly smooth. *Flowers* ± 23–30, 7–11 male, 16–21 bisexual, yellow, tipped pink. *Achenes* ± 0,75 mm long, elliptic. *Pappus* bristles very many, equalling corolla, scabridulous. *Chromosome number*: 2n = 22. Figure 23B.

New taxa

The name of a new taxon must be accompanied by at least a Latin diagnosis. Authors should not provide full-length Latin descriptions unless they have the required expertise in Latin at their disposal. It is recommended that descriptions of new taxa be accompanied by a good illustration (line drawing or photograph) and a distribution map.

Example:

109. *Helichrysum jubilatum* Hilliard, sp. nov. *H. alsinoides* DC. affinis, sed foliis ellipticis (nec spatulatis), inflorescentiis compositis a foliis non circumcinctis, floribus femineis numero quasi dimidium hermaphroditorum aequantibus (nec capitulis homogamis vel floribus femineis 1–3 tantum) distinguitur.

Herba annua e basi ramosa; caules erecti vel decumbentes, 100–250 mm longi, tenuiter albo-lanati, remote foliati. *Folia* plerumque 8–30 × 5–15 mm, sub capitulis minora, elliptica vel oblanceolata, obtusa vel acuta, mucronata, basi semi-amplexicauli, utrinque cano-lanato-arachnoidea. *Capitula* heterogama, campanulata, 3,5–4,0 × 2,5 mm, pro parte maxima in paniculas cymosas terminales aggregata; capitula subterminalia interdum solitaria vel 2–3 ad apices ramulorum nudorum ad 30 mm longorum. *Bractee involucreales* 5-seriatae, gradatae, exteriores pellucidae, pallide stramineae, dorso lanatae, seriebus duabus interioribus subaequalibus et flores quasi aequantibus, apicibus obtusis opacis niveis vix radiantibus. *Receptaculum* fere laeve. *Flores* ± 35–41. *Achenia* 0,75 mm longa, pilis myxogenis praedita. *Pappi* setae multae, corollam aequantes, apicibus scabridis, basibus non cohaerentibus.

TYPE.—Cape, Namaqualand Division, Richtersveld, $\pm$ 5 miles E of Lekkersing on road to Stinkfontein, kloof in hill south of the road, annual, disc whitish, 7 xi 1962, *Nordenstam 1823* (S, holo.; E, NH, PRE).

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REPRINTS

Authors receive 100 reprints gratis. If there is more than one author, this number will have to be shared between them.

DOCUMENTS CONSULTED

Guides to authors of the following publications were made use of in the compilation of the present guide: *Annals of the Missouri Botanic Garden*, *Botanical Journal of the Linnean Society*, *Bothalia*, *Flora of Australia*, *Smithsonian Contributions to Botany*, *South African Journal of Botany* (including instructions to authors of taxonomic papers), *South African Journal of Science*.

ADDRESS OF EDITOR

Manuscripts should be submitted to: The Editor, Bothalia, Botanical Research Institute, Private Bag X101, Pretoria 0001.

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